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ARTHUR LESTER LOVETT.

Arthur Lester Lovett, Professor of Entomology, Oregon Agricultural College and Oregon State Entomologist, died at his home in Corvallis, Oregon, Friday, April 25, 1924, of septicaemia poison.

Born at Neal, Kansas, August 23, 1885, he was called from us in the prime of life and at the time he was attaining national recognition as a leader among economic entomologists. Graduated from Oklahoma A. and M. College in 1906, Prof. Lovett acted as Entomologist for that institution and as state inspector until 1911, when he came to the Oregon Agricultural College as Assistant Entomologist. In 1917 he became head of the department of Entomology and State Entomologist for Oregon.

He was a recognized authority on the Diptera, especially the family Syrphidæ, in which group he has described many new species from the west. During the past few years little time was devoted to systematic entomology, but his untiring labor along economic lines brought him wide recognition among the fruit growers and farmers of the Northwest. Prof. Lovett was the first man to use spreaders for increasing the efficiency of sprays; this practice is now common throughout the country.

Professor Lovett's untiring labor in the field of science, his winning personality and upright character, has won for him a legion of friends who mourn deeply his untimely end. The Institution, the State, and the scientific world have lost a loyal worker, a true friend and a man whose place will not soon be filled.

Prof. Lovett was a fellow of the American Association for the Advancement of Science; Vice-President of the American Association of Economic Entomologists; a recent member of the Editorial Board, Entomological Society of America; a member of the California Academy of Science, Pacific Slope Entomological Society, Western Society of Naturalists, Crop Pest Institute of America, and the American Crop Pest Commission. He was also a member of two National Honorary Fraternities, Gamma Sigma Delta and Phi Kappa Phi.

He is survived by a widow and two children; his parents, Mr. and Mrs. H. W. Lovett, of Fort Collins, Colorado; a brother, A. E. Lovett, of Yakima, Washington, and a sister, Mrs. P. N. Annand, San Mateo, California.

W. J. CHAMBERLIN.

SOME HABITS OF EARWIGS.*

By B. B. Fulton,
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The presence of an earwig arouses in the average man and more so in the average woman, a strong feeling of disgust, possibly suggested by its sleek, sinuous body and by its secretive and nocturnal habits. At any rate, the feeling is almost universal and seemingly instinctive. Yet earwigs inflict no personal injury upon man, contrary to popular imagination and ancient superstition. A study of their habits reveals many qualities which are usually regarded by man as virtues, and still others which, if not so classified, are at least humanly interesting.

MATERNAL CARE OF EGGS.

The maternal care of the eggs and young by the female European Earwig, (*Forficula auricularia* Linn.) has been described as long ago as the eighteenth century, by the Swedish Entomologist, DeGeer (1). He told how he placed a female with her eggs in a sand box and watched her gather up the scattered eggs and place them in a pile. This is an experiment which anyone can easily perform. A flat dish covered with a piece of glass or a Petri dish partly filled with moist sand makes an ideal home for an earwig, where its habits can be observed. Last winter while studying the European Earwig in Oregon, I fitted up several such cages and placed in each one a female earwig which had been recently removed from her nest in the ground, and dumped the eggs in on the sand just as they happened to fall. Within a few minutes each earwig started to gather the eggs. In carrying the eggs, the female opens the mandibles and holds the egg between them by means of the palpi. Some of the females started a pile in a certain spot where there happened to be a number of eggs to start with and systematically gathered the surrounding eggs, one by one, and added them to the pile until it was complete. Others seemed more confused and would stand in one spot and take all the

* Contribution from the Department of Entomology, Oregon Agricultural Experiment Station.

eggs within reach and move them back under the body, then go to another place and repeat the performance. This resulted in a number of small piles which would later be combined into one. In about half an hour all the earwigs had the eggs piled and were standing over them or were rolling them about in the mouth one by one, apparently cleaning them.

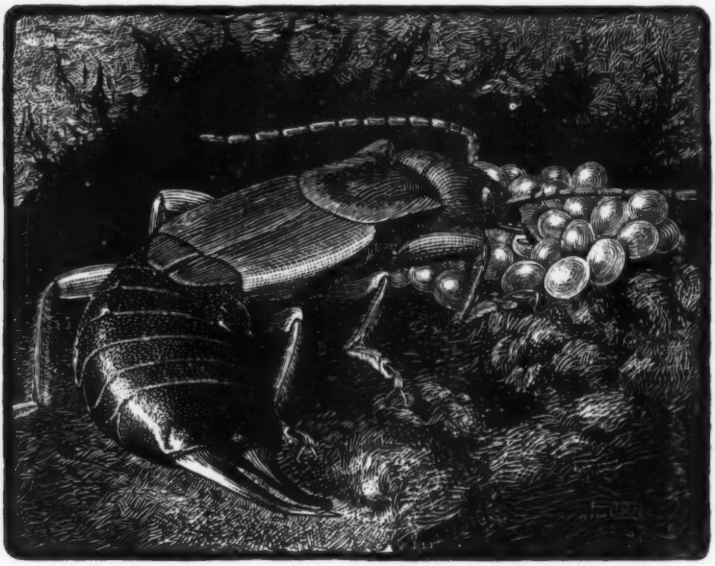

Fig. 1. Female European Earwig in underground cavity with eggs.

Within a day all the eggs had been carried into cavities in the sand which I had prepared and kept darkened by a block of wood over the cover. In cages where I left out the cavity the earwig dug a hole downward into the sand.

It happened that I lacked one cage of having enough to go around so I placed two females with two lots of eggs in one cage. This proved to be the most interesting cage of all to watch. At first each female began gathering eggs without noticing the other and two small piles were started. Everything was moving along peacefully until the smaller earwig of the two started out to hunt for more eggs and came upon the other pile.

She was about to remove one of the eggs when the larger female discovered her. A lively fight followed, with reckless disregard for the eggs, which were scattered in all directions. Each female tried to nip the other in the abdomen with her forceps. They went round and round without inflicting any serious injury until the small one became frightened and fled.

They again went about the business of gathering eggs but every time their paths crossed, there would be a fight. After several bouts, the smaller happened to find refuge in the small cavity which I had prepared in the sand. I left this cage for a time and when I came back the larger earwig had all the eggs piled except about a dozen which the smaller one had with her in the cavity. Presently the small earwig came out and approached the other pile of eggs cautiously, and attempted to remove one from the edge of the pile, but was driven away. She tried this several times and was driven away more vigorously each time. Finally the larger earwig followed her clear into the cavity and seemed about to settle the dispute there when suddenly the pursuer discovered the small pile of eggs. She immediately abandoned the fight and ran away with an egg to her own pile. From then on she paid no attention to the smaller earwig until she had removed every one of the eggs from the cavity and added them to her hoard, after which she stayed by to defend it. The smaller earwig when last seen was making a frantic effort to dig into the sand, completely vanquished.

No serious fighting took place in cages which contained male and female only. The female would turn her forceps in a threatening attitude whenever she would come upon the male suddenly, but seemed to recognize him at once as harmless and would go on about her business. If he happened to blunder into the cavity containing the eggs, she would use the forceps if necessary to drive him out, but after recognition would usually block the passage and push him away with her mouth. He was never permitted to remain. The males never attempted to dig cavities for themselves, but took advantage of existing crevices, no matter how poor the accommodations. In digging nests out of the ground, I have occasionally found male and female together. This agrees with the observations of T. A. Chapman (2), who studied the life history of the earwig in England. In his cages, many of the nests were occupied by a pair

of their own accord and he found similar cases out of doors. He says that he never observed the males licking the eggs, but that they assisted later in the care of the young earwigs. In Oregon, most if not all of the males come out of the ground before the eggs hatch. In my cages at hatching time the males spent all their time in an effort to get out, while before they had seemed content to remain.

All of the earwigs in my cages completely closed up the entrance to their caves within a few days, except one and in this case the entrance was directed toward the dark side of the cage. They also applied sand to the glass roof around the edges of the cell where light probably entered in spite of the cover. When digging, the earwig uses her mandibles to loosen the particles and works the loose dirt under her thorax with head and fore feet until a small pellet is gathered, then she takes this in her jaws and carries it out of the cell or uses it to chink up cracks. Out of doors the earwig probably occupies natural cavities to a large extent and blocks them off to suit her purpose.

The female earwig moves the eggs about frequently during the incubation period, each time cleaning them off and carefully re-piling them. The egg increases in size as the embryo develops; its surface approximately doubles in area. The internal pressure acquired during this growth can be demonstrated by dropping the egg on a smooth hard surface. It will bounce like a new tennis ball.

The hatching process starts suddenly by the bursting of the shell at the head of the embryo. In two or three minutes the young earwig has its limbs entirely free and attempts to crawl about. The adult earwig does not assist the new arrival in any way and may even trample over the helpless creature in her effort to move her precious eggs about. If the young one gets in the way of the eggs, she may pick it up and deposit it in an unoccupied part of the cavity where it will remain until its skin has hardened and acquired an olive gray color.

MATERNAL CARE OF THE YOUNG.

For a few days after the young earwigs appeared in my cages, the female earwigs kept the cracks of the cells tightly closed up with sand to prevent their escape. After that the nursery chambers were opened to the outside. A few of the eggs in

each case failed to hatch and turned a gray color. The female took care of these until all possibility of hatching was long since past.

A nest of young earwigs is a most interesting sight; they seem to fill the cell—a squirming, writhing mass. The old earwig standing in their midst with the nymphs crawling under, over and about her, reminds one of an old hen with a brood of chicks. She occasionally moves one of them by grasping the body of the nymph with her palpi. It is curious to watch the young earwigs reach up and touch the mouth of the mother. Occasionally I have seen four or five of them struggling with each other to attain this purpose and often one will cling to the underside of the mother's head, mouth to mouth. They appear so eager that I suspect she is feeding them something by regurgitation, but the position of the head is such that I have never been able to detect any substance pass between mother and young.

I placed cut pieces of insects in the outer part of a cage and they were carried into the cell by the female and devoured by herself and the nymphs. In other nests I sometimes found pieces of dandelion flower that had been placed in the cage for food. Later I saw a female carry a piece of dandelion into the nest and deposit it for the young ones to eat. Most of this family were already in the second instar, but I had never seen more than one or two of them feeding in the outer part of the cage. The nest was littered up with the remains of dandelion flowers. At nights most of the adult earwigs, and only a few of the nymphs would be found feeding outside of the nests. I believe that the nymphs normally remain in the nest until sometime after the first moult.

The females do not seem to discriminate between their own offspring and those from other nests. If a young earwig wanders away from home, it will find a welcome and free lodging in any earwig nest that it can find. I had two nests in one large dish. In one the female seemed indifferent to the young a few days after they hatched and she brought no food to the nest. The other nest had pieces of dandelion flowers in it. Within a few days the nymphs had all left the first nest while the second was crowded to capacity, and I believe it contained both families. I have taken nymphs from one nest and introduced

them into another. In all cases they would mingle with the crowd and would be accepted without the slightest indication of hostility.

The maternal instinct of the earwig is not an ephemeral thing which disappears when the object of it is removed. A female that I dug out of the ground was deprived of her eggs for three days. She was then given a small set of eggs, which she gathered up and cared for as if she had always been with them. Another female was caged apart from her young for two days. When replaced in her former cage she entered the nest and assumed her duties as before.

I wished to test the ability of the female earwig to protect her young from enemies so I introduced a ground beetle (Carabidæ) nearly half an inch long into one of the cages. The earwig did not hesitate to attack the ground beetle and did it with such vigor that the latter hurriedly sought refuge in the sand. I can not see what harm an earwig could inflict on as well armoured an insect as a ground beetle. Perhaps it was all bluff but it seemed to be effective, although in this case the beetle was probably already frightened by the new situation and recent handling.

In another cage I placed the predacious larva of a ground beetle, about as long as an adult earwig. It soon wandered into the nursery chamber and a lively encounter took place. The larva tried to escape into a blind passage near the mouth of the earwig cavity. It turned to come back but found the earwig blocking the passage with her forceps and every time the larva came close enough it received a pinch or a jab. The earwig was so situated that her head and thorax blocked the entrance to her nest and seemed to have settled there for an indefinite stay. After about five minutes the ground beetle larva made a break and escaped but was severely pinched.

Again it blundered into the earwig nest and this time the earwig's forceps caught it in the middle and held on while the larva lashed its body about and bit at her abdomen. Young earwigs fled in all directions and took refuge in the first tight corner they found. Finally she released the larva and it crawled away with the hind part of the body temporarily paralyzed.

Gradually the little earwigs drifted back to the cell. At such times they seem to sense the protection of the mother and

huddle quietly together. The female looks about and touches each one she meets with her antennæ.

After the larva had recovered from the last encounter I placed it where it would crawl into the earwig nest again. This time the earwig pursued it out into the open and got a grip on its middle which completely paralyzed it for a time. It lay on its back helpless and if she had followed up her advantage I believe she could have killed it. As it was she jabbed at it a number of times without getting another good hold and pushed it further from the nest and left it.

The earwig's method of fighting is awkward, a blundering hit or miss process. In a narrow underground passage it can effectively guard itself from a rear attack, but in more open ground it first has to locate its antagonist by means of the antennæ, then reverse its position and bring the forceps into play. By that time the enemy may be in another place. When advancing to attack, the earwig curves the abdomen upward or to one side so that the forceps are directed forward and can be more quickly brought into use. Whenever an earwig is disturbed it flexes the abdomen upward with the forceps held wide open. This has been described as a "frightening attitude" and so it may impress a human, but I do not see how it could have such an effect on so unimaginative a creature as a ground beetle.

A ground beetle or its larva or even a freshly cut piece of one of them will cause an earwig to assume a fighting attitude the instant it comes near enough to be touched with the antennæ. On the other hand, some ordinary "sow bugs" that I introduced into one cage mingled freely with the earwigs. Even from the first the earwig did not attempt to fight with them, either in defense or to kill them for food, although they readily ate cut pieces of sow bug.

USE OF THE FORCEPS.

The use of this most characteristic part of the earwig's anatomy is often referred to in works on entomology as "obscure" and authors prefer to pass over the subject with a few very general remarks. From a review of the literature on earwigs and from studies of living material of two species there is no longer any doubt in my mind but that the forceps

are very useful organs and that their function varies to some extent with the species.

The most important use seems to be that of defense. As a dweller in holes and crevices the earwig needs some means to protect itself from a rear attack. Burrowing insects are usually provided with some such means of defense, long spines, heavily chitinized shields and glands discharging fetid or viscous liquids. I have already shown something of the earwig's ability to defend itself from ground beetles and their larvæ, and no doubt they can protect themselves and their nests from a great many small, predacious insects.

The use of the forceps as an offensive organ seems to vary considerably with the species. The Little Earwigs (*Labia minor*) do much fighting among themselves. They are very active and run about through the rotted manure of old piles where they are often found in large numbers. When two of them meet there is apt to be a fight with the forceps, resulting in the prompt retreat of one of them. They can turn quickly and make their thrusts with fair accuracy and may even follow a retreating opponent a short distance by running backward. A choice morsel of food is always an object for conquest and may change hands several times before it is completely devoured. I have never found them hiding in clusters like the European Earwig, but on the other hand, they seem to avoid each other.

Although the European Earwigs ordinarily seem to lead a rather peaceful community life, I have seen them fight hard over a morsel of food in cages where they had not been fed for some time. An earwig lucky enough to get hold of a piece of food would turn this way and that without interrupting its feast and with the forceps drive away other earwigs that approached. If another earwig discovered the food it would perhaps take the aggressive and attempt to drive the owner away. None of these conflicts seemed to inflict any injury on any of the participants.

Several species of earwigs have been said to use the forceps as a means of offense against other insects. Bennett (3) says that he has seen the Maritime earwig, *Anisolabis maritima* (Gene'), in cages chase and catch with their forceps crickets, sand-fleas and smaller earwigs and devour them while still holding them with the forceps. Sopp (4) describes a case in which a female *Labidura riparia* (Pallas) captured with her forceps and

devoured a blue bottle fly which had alighted near her hiding place. Later he saw a male thrust its forceps backward into a hollow among some sea weed and pull out a large fly which was squeezed to death by the forceps as he dragged it away. The fly was held in the forceps until nearly half eaten. I have seen *Forficula auricularia* devour a live blow-fly maggot nearly half as large as itself without resorting to the use of the forceps. The maggot was held by the front legs and while it was struggling the forceps were brought around to one side as if to have them ready if anything unexpected happened. *Labia minor* ate some small, active manure maggots without using the forceps, although several attempts were made by different individuals before these maggots could be overpowered.

The use of the forceps in connection with folding and unfolding the wings is more obscure because these insects are seldom seen in flight. It has been frequently stated that the forceps of the earwig are used to complete the process of packing away the wings after flight. I wished to verify this statement but it seemed hopeless to wait for *Forficula auricularia* to fly voluntarily so I forcibly opened up the wings of a few individuals. In the case of the first two earwigs so treated the delicate membrane was crumpled or torn and would not again assume its former folds. These two made no attempt to use the forceps to refold the wings, but the unfolded wings seemed to irritate them and they pawed at the wings with the middle or hind leg and also rubbed the part against some object. With two other earwigs, a male and female, I got the wings partly expanded without injury and watched the folding process to completion. After quieting down the earwig brushed the wings a few times with the middle legs, then seemingly with considerable effort it raised the tegmina and the wings automatically dropped into their former folds apparently due to the elasticity of the membrane. Then the earwig brought the forceps up over the back and made a few passes from side to side across the wings, helping to tuck in the distal cross fold. Then the tegmina were dropped and the wings flattened into place.

Cook (5) says that in the case of *Labia minor* the insect uses the forceps to comb out the wings, and is apparently unable to resort to flight without the assistance of this organ. I made this observation myself by placing earwigs of the same species on a large cork standing in a pan of water. These insects take

to flight more readily than *Forficula auricularia*, which is rarely observed flying. As soon as one of them finds that it is hopelessly marooned it raises the tegmina and folded wings, brings the forceps up over the back and begins to comb the wings alternately with an upward stroke. The wings are kept moving all the time and as soon as one wing is open it continues to vibrate until the other is unfolded. The movement ceases for a moment, the wings poised in a horizontal position, and then the earwig flies away. During this process the forceps are held open. The points catch and pull out the cross fold of the wing, which lies near the base when folded. Some of the females were unable to straighten their wings, although they made repeated efforts. The first wing opened would snap back into place while the insect was working on the other one. As soon as an earwig alighted after a flight the wings would close instantly without any special effort on the part of the insect.

Apparently the forceps are necessary for flight in this species. I took one male which had made two flights without difficulty and cut off the forceps, leaving only short stumps. This male made repeated efforts to fly but was unable to open either wing.

MATING.

During the latter part of the summer and early fall the European Earwig remains above ground at least at night and continues to hide by day in any convenient crevice. At this time mating probably occurs frequently and possibly occurs at any other time of year that the adults of the two sexes are found together. A pair which were brought in from hibernation in January copulated within a short time after being placed in the cage together. The male does not use its forceps as claspers at any time during the act. After he has located a female with his antennæ, he turns around and tries to slip the forceps under the tip of the female's abdomen. At this time the two are facing in opposite directions. It is then necessary for him to twist the body around so that the two ventral surfaces are together, the ends of the abdomens touching, the forceps of each extended along the ventral side of the other's body. In this position coitus takes place and lasts usually for a matter of hours, if the insects are not disturbed. A pair which started at 12 P. M. was found in the same position at 8 A. M.

In my large breeding cages, the earwigs were usually clustered together in the corners. In mating the male usually stood on one side of the corner and the female on the other. This required the male to twist his body only ninety degrees instead of a half revolution as would be necessary if they were both on the same surface. In nature the earwigs always seek narrow crevices in which to hide. I supplied them with a retreat of this kind, made of two pieces of glass covered with wire screen, with a quarter inch space between. In this a number of pairs were observed in coitus, but always with the male clinging to one surface and the female to the other so that no twisting of the body was necessary. This is probably the normal position.

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NOTES ON CAPTIVE COLONIES AND HOMING OF BOMBUS PENNSYLVANICUS DE GEER.*

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While normally these bumblebees nest under a heavy mat of grass on or beneath the surface of the ground, there are occasionally queens which leave the beaten path of tradition and found colonies in unique situations. I have recorded (Trans. Acad. Sci., St. Louis, 24:40-41, 1922), one such nest in an old paint bucket, hanging on a barn wall seven feet from the floor; this bucket, after the paint had dried up, had been used by wrens the year before, and here among the sticks and straws was a growing colony of bumblebees. A second nest was found in a sack filled with straw lying on the floor of an abandoned club-house.

Since these records were made, two other colonies were found in which this species had built elsewhere than on or below the surface of the ground. The one was an enormous colony which had nested between the ceiling and upper floor of an abandoned log house at Horine, Missouri. The bees gained access to their nest through a crack in the ceiling, and came and went through an open door some distance away. The other nest was in a hollow tree, six feet above the ground; it was in the old nest of a white-footed mouse. On June 9, 1922, it contained a queen and three waxen honey-cups, filled to the brim with honey, and a fourth cup partly made. In among the straws and grasses, threads and seed-pods, and beside the dainty mummy of the deer-mouse, this mother was laying the foundation of a promising colony.

These details are brought out because they suggested to me the possibility of colonizing the bees on the roof of my home in the city. Three colonies were thus transplanted, and the details that follow will show that it is possible to bring the colonies close to the study, and thus work out many problems at close range. The work, however, can, as I sadly learned, be carried on only by stealth, because, should the bees err in returning home

* Identified by Mr. S. A. Rohwer.

and enter the window of the wrong house, a panic is likely to ensue, with the result that one probably loses good bees, or good neighbors, or both.

Three colonies were taken in St. Louis County, and transferred to cans or pots and placed on the roof. The nests were always etherized, and when the bees became unconscious, they were picked up and placed in a box. The nest and mass of surrounding material was then scooped up and placed in another box. The greatest hindrance to this daylight method is the fury of returning workers that have not shared the ether. It is surprising how small the mortality is with this process, even though the bees are so stunned by the ether that they seem almost dead. In one nest of 28 individuals, 24 recovered, and in another nest of 63, 60 recovered from the effects of the ether. One must work at top speed, however, to spare them an unnecessary second under the anaesthetic. They can easily be transferred from the box to the cage prepared for them, by making a small hole in the box and taking them with the forceps one by one as they poke out their heads.

The three nests which I took by this method were all in the grassy portions of a field or yard, each in a bowl-like depression in the earth, filled and covered with thick masses of grass. The bees seem to like situations where the grass grows tall and falls over, year after year, thus making a thick, soft mat. I have concluded that the bees are responsible, at least in part, for the well rounded cavities in the earth; the depressions hardly seem to be the kind that could always be accidentally found. Since the bees in the pot of earth and sand on my roof have demonstrated that they can and do dig, it seems reasonable to think that in nature they would utilize this faculty in nesting.

One of these nests was taken at Hillcrest. The depression in the earth under the mat of grass was well rounded, six inches in diameter and three and one-half inches deep. The brood-cells in three large masses were scattered or packed among grass and moss, evidently material brought in by the bees, and not in this case a rodent's nest. The nest was opened about noon, August 22, and 63 adults taken. During the hour following, 15 workers returned and tried to enter the broken nest. This gives a population, for this nest at this time of year, of 78, and also points to the fact that only 15 were out of the nest at a time, even at midday.

The other two nests were discovered at Wickes on September 1, 1923. One was situated near the path in the yard, where the occupants of the club-house had trampled and injured it. All day long, from six to eight males were hovering about this nest. Upon opening it, I found only two bees, which were queens. This accounts for the activity of the males on the outside. The combs were empty and scattered. The nest material as well as the combs harbored many crawling caterpillars, which in my jars developed into a moth belonging to the family *Pyralidæ*. These moths may have been responsible for the weak condition of this colony, for within a few feet of this nest, another was unearthed which had 28 adults. Of only this I am sure, however; it is possible for the moths to breed without the presence of the bumblebees, for the next season I carried on another generation in the jars with the waxy combs, but without live bumblebees.

One colony, a queen and about twenty workers, presented to me by Mr. Richard Lange, was placed in a large flower-pot half filled with earth and covered with a sheet of glass, (Fig. 3). The date was July 29, 1922. The bees ate ravenously of the honey which I placed in a shallow dish, and when this was entirely gone, they dumped some small dead larvæ into the dish, and then they began slowly to build a waxen floor over the debris, by breaking up the honey-cups and using the wax for this purpose. All day long, from two to four workers at a time were busy at the task, and by nightfall they had a thin, bumpy film of this material half covering the dish. They did not work at this at night, but their daytime activities were always under the cover of darkness, since the sheet of glass covering the pot was always (excepting a few moments at a time when observations were being made) heavily covered with opaque material.

The next day this film was extended to cover three-fourths of the area. On the wax plane they left three round holes, one-fourth inch in diameter, in a row, the use of which I could not understand. The perifery of these holes was built up in a sort of collar, and if a bag had been added to the bottom, they would have made typical honey-cups. This work continued until this plate of wax completely covered the tin dish, excepting six round holes. What this work would lead to I could not conjecture, but I had the idea that, in all probability, this would

serve as a foundation for a new nest. Resting in peace of mind with this surmise, I was surprised one evening to find that this entire floor which they had made, had been removed entirely, and the wax had been again used in cup making on the original site. Why this abrupt change in their course of action, I cannot surmise.

Later, the bees excavated under the dish and piled much of the rubbish on top of it, and thereafter, occasionally when a dead larva had to be disposed of, it was dropped on this pile. Just what may have been the purpose of this digging, I do not know, but in the three colonies under observation, it occurred in all. In one, there was very little space between the sand and the glass lid over the flower-pot, and the bees excavated directly beneath the cups, thereby lowering them and making it possible for them to finish and use the cells. Another colony known as the Hillcrest colony, showed unusual digging propensities. These bees and their combs were placed in a flower-pot three-fourths full of sand, and a small tin lid filled with honey was placed at one side. They were left thus at 10:30 p. m.; at 8 o'clock the next morning the lid and honey were completely covered with sand, not merely covered, but the sand was heaped high in a pyramid over the place. Their reason for this behavior, I have not fathomed; the other colony did not display such apparent resentment to my proffered aid. The latter, however, had lived in the laboratory for a week, had been fed on molasses, and had learned to eat what was supplied to them, while the former showed their resentment at my compulsion not only in spurning my offer, but in treating it as something enemical.

To resume the account of the first colony, in feeding them I placed large drops of honey on slips of stiff paper and slid them under the glass lid; thus they consumed large quantities of the honey. They soon became so greedy that they even scraped off the surface of the paper in their eagerness to get all the honey. Even in the darkness of midnight, they were found feeding. After two days, I found that six honey-cups were filled with pure honey. Since these cups were empty when the nest was placed there, and since the workers had not had access to the out-of-doors, this honey had undoubtedly been carried from my supply.

Next I placed this colony in its flowerpot on the roof outside my third story window, (Fig. 3). After adjusting a window-shutter to shade the pot, and placing beside it a red brick and a milk bottle that would serve as landmarks, I gently slid the glass cover back an inch, so they could fare forth if they so wished. I withdrew and watched eagerly to see their conduct in their strange new location. "If they do leave the nest," thought I, "will they find their way back? Here are bees which originally had their nest beneath the surface of the ground, now exposed on a second-story roof, twenty-five feet above ground; what will be their course of action?"

It was precisely ten minutes before the first bee crept to the opening and flew out. But she did not fly away immediately; she spent two minutes flying about the pot in zig-zags, figure eights and S's, and then repeated the same designs in larger flights around the region, often circling back past the pot in her flight. After four minutes of this wider flight, she soared high and flew over the third story of the front part of the house. However, she did not dash away to the park across the street, but spent some minutes in getting her landmarks about this new portion of the roof also, and even after I thought she had gone, she reappeared and once more circled about the nest. The precision of her flight of orientation is well worthy of note; first she spent two minutes very near the nest, then four minutes in wider flight about the roof, and then a few minutes exploring the larger aspects of the roof and apparently getting them linked up with the details of her new home site.

Now for a terrestrial creature to try to find her nest on this roof is exceptionally hazardous, for here are four houses so exactly alike that often the human occupants mistake one for the other. Fig. 1 shows the rear upper portion of this row of houses, and the dismal foster home of my colonies. I did not doubt that this bee would find her way home, because of her careful study of landmarks, but I did expect her to become confused by the many similar roofs. After an absence of ten minutes, she reappeared and, to my amazement, flew direct to the nest. After arriving at the nest, however, it took her two minutes to discover the small aperture in the glass cover. She walked about among the crowd of workers until I lost her to view. She somehow got rid of her load of yellow pollen, and left again in five minutes. She flew to the opening and this time

dashed away without any flight of orientation. After only eight minutes she returned, again laden with pollen, and flew to her nest and entered with even less difficulty than she did the first time.

When next I placed the Hillcrest nest on the roof and slowly slid back the cover, one bee near the entrance angrily flew out in reckless haste, without looking to her right or left; then, although she spent much time trying to find the nest, she never succeeded, and after fifteen minutes, she wandered further and further in her searches for it, and was lost. Others which followed were more circumspect, and explored the nest and the roof before venturing away. That night when I took my census, none were missing but the foolish virgin.

I left their glass cover ajar all night, and the next morning when I arrived at 6:30, several bees were already coming in loaded with pollen. It later became evident that these bees, like those in nature, sometimes remained out all night. At midnight, September 6, I closed their glass door, and at 6 a. m., I found three bees on the outside, trying to get in. In the open, one often finds a solitary worker asleep on the vegetation, as though nightfall had overtaken her far from home.

The contrast in the manner of those leaving the nest for the first time and the experienced travellers, as recorded above for one individual, seems to be constant; the former fly deliberately about the pot and its environs in ever enlarging circles for from five to seven minutes before they venture away; the latter, already familiar with their surroundings, dash off with a whiz, direct to the foraging field.

The same behavior occurred some years ago in the case of the colony in the wren's nest in the paint bucket. This was kept on a table in the cellar; the cellar was dimly lighted, and an open window 25 feet away served as an exit and entrance. Here, too, the bees made a careful survey about the bucket and again about the window when first they ventured forth, and thereafter they were able to go and come by direct flight.

One worker came in heavily laden with pollen, and walked about poking her head in several cups, as though not knowing where to drop it. Then while she held her head in one cup, a companion on one side of her and two on the other side completely removed and actually ate the masses from her legs. At first I thought they would carry it into the empty cups,

and I was much surprised at this beahvior. Normally the pollen loads are quickly deposited without the assistance of fellow workers. The two hind legs, and sometimes a portion of the abdomen, are thrust into a waxen cup, and a few scrapes of one leg against the other drops the load. When only the legs are inserted in a half-filled cup, one can nicely see just how it is done. When the cup is nearly empty, the bee backs into it, shakes off her pollen, and then turns around and packs it down into a firm, smooth mass. It is surprising with what dexterity the bees perform these activities.

The workers like to eat pollen, at least under these artificial conditions. On several occasions I saw the workers pause beside the full pots and eat their fill, thereby noticeably diminishing the supply. There is a possibility that some of it might be regurgitated and fed to the larvæ.

The bees come in laden with pollen as early as 6 a. m. They do not unload into one cup until it is filled, but drop a load here or there, until several cups are in various stages of fullness. Some are more fastidious than others and spend several minutes looking into various cups before depositing the load. One consumed eight minutes in such a search before she found one to her liking. This is about as much time as it takes to harvest a load.

By August 13, the members of one colony were breaking down their old wax work and building new pots with this material. This process exposed several small larvæ. These they ruthlessly threw out on the sand or carried out and dropped on the roof. These larvæ may have been dead, but there was no discoloration to indicate that condition. This shocking infanticide can be justified only by the unusual conditions under which the bees were living. However, in another colony nearby the larvæ were not molested.

After the Hillcrest colony had been active for four days, I noticed in several brood pots that contained either eggs or young larvæ, from six to eight globules of honey on the walls. These had been placed there for the young to feed upon, and in one case I actually saw a three-day old larva stretch itself horizontally across the inside of the cup to the drop on the opposite wall, where it imbibed greedily of the honey.

During the time when I kept the flowerpot cages in the house, the bees became so accustomed to my presence and

handling that they were comparatively docile, but a few days of normal quiet and seclusion on the roof made them susceptible to any slight jar, so that at a touch they were aroused to pugnacity. On one occasion a slight disturbance had thus aroused them to anger, and about half of them suddenly flew out. Since many of them were young and inexperienced, it was with great difficulty that they came back; they buzzed about the roof for more than half an hour, and five of them were permanently lost. Thus mob psychology leads even these little creatures to reckless and disastrous action.

After two weeks of my presence, the bees of one colony became amazingly tame; I could completely remove the glass cover and hold my face close to their work with perfect impunity. They had become so accustomed to my prowling that it was no longer necessary to cautiously slip pieces of honey laden paper under the glass, but it was easy to drop it directly into their cups.

In the afternoon when the roof became very hot or when I failed to replace the shutter that gave them shade, a system of ventilation was installed. From one to four bees took a position at the entrance and rapidly vibrated the wings for long stretches of time. They would cling to the inside rim of the pot, with the wings somewhat lower than the glass lid, in a position that would pump the old air out rather than fan new air in. Sometimes the position was such that only half of the wing was below the level of the lid, but it accomplished the same purpose. It was indeed marvelous to see their great persistence in the activity of the moment. Plath* records similar behavior for *B. impatiens* and *B. fervidus*, and gives a highly interesting review of the literature on the subject of nest ventilation in bumblebees.

The object in bringing these colonies to my home was, first, to get acquainted with their habits, and then to experiment on their homing propensities. I had just completed a series of experiments on two species of bees, *Anthophora abrupta* and *Xylocopa virginica*, wherein I had found that age and experience were factors controlling their homing activities. Since we had not the early history of these colonies, the work in this case had to be done without the accurate knowledge of the ages.

* Psyche, 30, 146-154, 1923.

A few of the bees, to be sure, had emerged here, and knew no home but the roof, so the only handicap to their return from normal flights would be the abnormal environment of the nest. But even these must exercise a strenuous modification of their ancestral habits of homing. The majority of the bees, however, were those which had formerly known their own old homes, but in this new land of bondage had re-educated themselves in middle life—a most difficult feat for the best of us—and were applying this new knowledge with remarkable success. In their case, both the chain of ancestral habits and the chain of individual habits or education acquired in youth had to be broken down and replaced by new responses. So let it not be forgotten that whatever success they may attain in the long test flights is of less real importance than the fact that they can and do return from their foraging flights to a home in a new and abnormal location. The experiments will show, however, to what extent it is possible for the bees to find home, and the distance from which some of them at least could return.

The pots containing the colonies were kept on the second story roof (Fig. 1), where I had easy access to them through the third story window. Most of the bees, when they went foraging, flew over the third floor roof toward the east, crossed the street and entered the park (Fig. 2), and in returning they followed the same route over the high front of the house and down to the lower roof to their nests. They succeeded exceedingly well in finding their location, in spite of the fact that the four houses were just alike. The fronts of the houses, facing the park, were also alike, so the bee coming home was confronted with four houses, all alike, from which to choose her own—a task which exacted more than casual attention from the human occupants.

The experiments in taking marked bees out for homing flights were made on September 6. The bees had then had more than thirty days in which to become acquainted with the neighborhood. On that morning at seven o'clock, bees in two nests were divided into four lots and each bee taken in the forceps and given a dab of color on the thorax, corresponding to a recorded number. Each cage was wrapped in several layers of newspaper and carried by automobile to the point where they were to be liberated. Only those which flew out nimbly when liberated were considered; if a bee was sluggish, it

was carried back to the laboratory and not used in these experiments, to avoid the chance of their ill health or injury influencing our results.

Experiment I. Ten bees from the Hillcrest nest were marked with white and carried to the Grand Avenue gate of Tower Grove Park, a point 1½ miles east of my home. They were liberated at 9:30 a. m. Only one bee returned, and that not until the early morning hours of the second day, for when I awoke at 6:30 a. m., I found her trying to enter her nest.

Experiment II. Nine bees, marked in red, taken from the same nest as above, were liberated at the Alexander von Humboldt statute in the park at 9:03 a. m. This is one-half mile east of the house. Three of these bees returned the same day, one each at 9:15 a. m., 9:50 a. m. and 12:50 p. m., making the trip in 12, 47 and 225 minutes respectively.

Experiment III. Nine bees, marked in yellow, were liberated at 9:27 a. m., at the gate 1½ miles east, as in Experiment I. None of these returned.

Experiment IV. Six bees from Webster nest, marked in blue, were liberated at the von Humboldt statue, at 9:08 a. m. Only one from this lot returned, at 3:30 p. m., after having been afield six and one-third hours.

Experiment V. Thirteen bees, two of which were queens, seven from nest A and six from nest B, were liberated at the von Humboldt statue at 10:55 a. m. This test was especially interesting because of the fact that the bees of nest B had always eaten greedily of what I gave them, but had never ventured forth to forage for themselves. This was their first trip away from their new home, but it was for only one-half mile. Of the thirteen bees, only two returned, one at 4:30 p. m., and the other at 6:45 the next morning, having been away from home 5½ and 19½ hours respectively. Both of these successful contestants were from nest A; all from nest B were lost.

Experiment VI. While I was waiting for the marked bees to return, others that had been foraging came back to the nest. While the first four experiments might have been carried on in part with young individuals, I knew that in this case I had experienced travellers, bees that had been out foraging over the region, for here before my own eyes they came home laden with pollen.

In the first five experiments, the bees had been liberated in the park east of the house, apparently in their usual foraging ground; now we liberated them west of the house, where the returning bees would have to fly over housetops and piles of clay drain-tiles, stacked in monotonous rows covering several acres, (see Fig. 4). I suspected this was a neighborhood not known to them in their foraging flights.

Fourteen of these bees, all taken out for the first enforced or trial flight, and one which had made the trip successfully from the point one-half mile east, were taken out and liberated only one-fourth mile west of the house, on a busy street. Only three returned, and the one that had made a previous flight was not among them. Two returned in 12 and 14 minutes, respectively, and the third one came in the next morning at 6:15, having been out about 18 hours. Even though all had had worldly experience, only three out of fifteen made the flight from one-fourth mile west. This indicates that their foraging experience in the park east of the house was of but little use to them in strange, new territory.

Experiment VII. The three bees which made the successful flight in the last test were again taken to a point one-fourth mile northwest. The landscape was similar to that west of the house. Only one returned, and did so the next day, after a mysterious absence of about 25 hours.

Exp.	Number Liberated	Distance, Mile	Direction from Home	Number Returned	Absent, Hours
I.....	10	1½	East	1	20
II.....	9	½	East	3	1/5, 4/5, 3¾
III.....	9	1½	East	0	
IV.....	6	½	East	1	6⅓
V.....	13	½	East	2	5½, 19½
VI.....	15	¼	West	3	⅓, ¼, 18
VII.....	3	¼	N-west	1	25
	65			11	

The table shows that out of 65 bees taken out on test flights, only 11 returned. Out of 19 taken 1½ miles east, only one returned, or 5 per cent; out of 28 taken one-half mile east, 6, or 21 per cent returned.

While the results would have been more illuminating had a larger number been employed and the ages known, at the same

time the experiments are significant in that they show that at least one bee is capable of finding its way to a new home from a distance of 1½ miles. There is evidently much variation in their ability to find their way home. This work should be repeated on individuals of known age, to determine whether the greater proportion of those that succeeded are middle aged or old and experienced bees, as we have found to be true in *Polistes pallipes*,* *Xylocopa virginica* and *Anthophora abrupta*.†

These experiments again bring to light the great difference in the amount of time consumed by different individuals in finding their way home, probably due to their varying success by the trial and error method. This variation in time does away with the idea here, as it has in many other cases, that the creatures find their way home by an unknown sixth sense or by magic, for if they did so act, all would return at or about the same time. It also shows that the homing instinct *per se* does not influence these creatures, for if it did they would fly back immediately to their original home in the woods. These simple tests prove instead, that part of the bees at least must have forgotten the memory pictures of their old home, and formed and retained new impressions that were sufficiently strong to bring them back to the very unnatural environment of a nest in a flowerpot on the house-top of a city dwelling. If only one bee had returned, it would have been enough to bring to their knees the entire school of philosophers who maintain that insects are guided home by some magical sense.

Some naturalists have written on the hive odor and the queen odor of honey bees. The behavior of one lot of these bees pointed to new problems in this line. Each wire cage containing marked bees was wrapped in several layers of newspaper, and usually two cages at a time were taken and the bees liberated at one point. The method was to carry two cages to a point at an accurately measured distance, open one cage and, as soon as the insects had flown, open the second one. This was done without difficulty in every case but one. The bees usually flew away calmly or turned their attention to the dandelions and other flowers near by, and gradually wandered away. In the exceptional case, however, (Experiment 5) when the first cage was opened, the inmates seemed agitated and

* Wasp Studies Afield, 244-280, 1918.
†Paper in course of publication elsewhere.

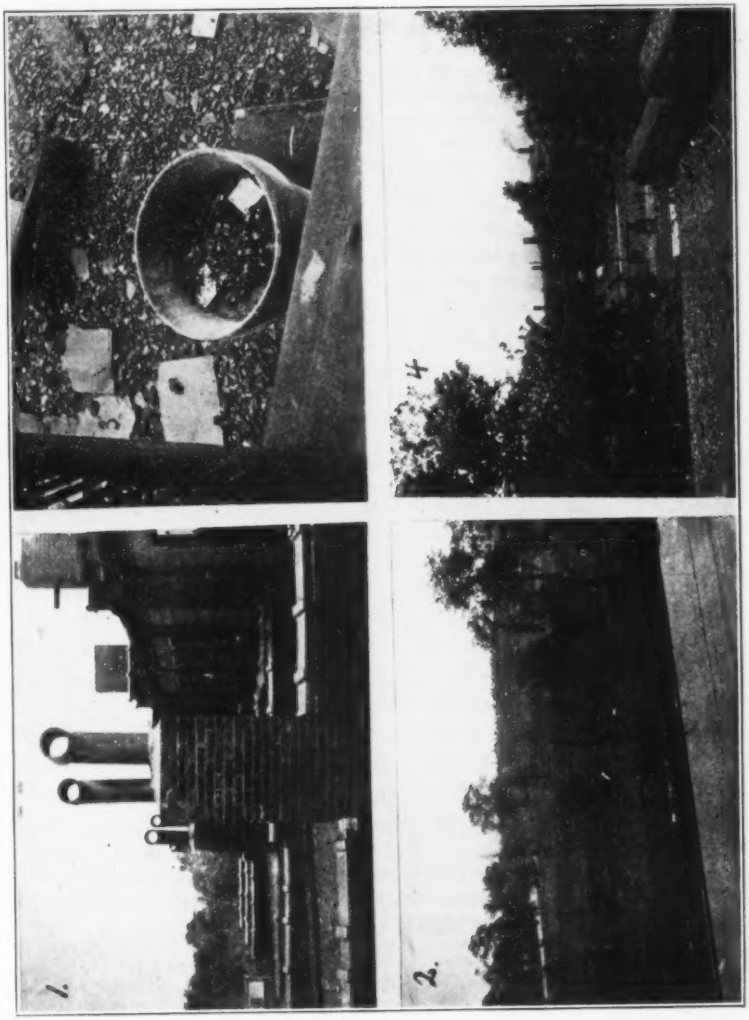
buzzed and circled about the head of my wife, who was liberating them. While she stood motionless and rigid, to avoid being stung, they persisted in their angry and excited buzzing about her, beating themselves repeatedly against her face and shoulders and trying to crawl in between the folds of paper enclosing the other cage under her arm. This continued for eight long minutes, until the tension became so great that she dropped the other cage and ran. From a distance she could see several bees hovering about the spot for twenty minutes more; then she came home and returned after an hour to get the other cage and open it. Even then two big bumblebees were grumbling about in a tone of voice that was not soothing, but she reclaimed our cage in spite of them. This new line of action was most puzzling to us until we consulted the records and found that this remaining cage contained two newly emerged queens. It seems remarkable that this queen odor should be perceptible to the others through several layers of paper, but that is the only explanation that I can offer for this enigma of their very conspicuous conduct. These two lots of bumblebees came from two distinct colonies, so the case seems to be one of queen attraction and not family- or nest-attraction.

While this work is rather more suggestive than conclusive, it opens the way for carefully planned experiments to test for bumblebees the value of various theories that relate to species odor, family odor, queen odor, etc., that have been formulated by Lubbock, Bethe, Forel, Buttel-Reepen and others for ants and honey bees.

St. Louis, January 15, 1924.

EXPLANATION OF PLATE XXXIX.

Fig. 1. The roof upon which the pots containing the colonies were placed.
Fig. 2. The view east of the house.
Fig. 3. The pot containing the comb of a colony of bumble bees on the roof
Fig. 4. The view west of the house.



Phil Rau.

LIFE HISTORY AND HABITS OF TWO PACIFIC COAST BARK BEETLES.*

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INTRODUCTION.

For many years two species of engraver beetles have been doing considerable injury to Monterey pine (*Pinus radiata* Doug.) along the central part of the California coast region. These two species are very similar in appearance and habits, and at first, both were included under the name of *Ips plastographus* Lec., a species described by J. L. Leconte in 1868. For a long time, however, it was known that two species were represented, and that these could be readily distinguished by the character of the larval mines. They could also be less readily separated by the arrangement of the spines on the posterior declivity, and by the punctures on the elytra.

Several years ago Dr. A. D. Hopkins gave this second species the manuscript name of *Ips radiatæ*, and when the writer began the observations given here, Dr. Hopkins published† the cardinal characters separating the two species. Being in the Monterey pine belt a few years the writer had an excellent opportunity to study the life history and habits of these beetles and wishes to express his appreciation for the assistance given by Dr. V. L. Kellogg and Professor R. W. Doane, of Stanford University.

PART I.—*Ips Plastographus* Lec.

DESCRIPTION.

The adults are small, dark brown to blackish beetles, averaging five millimeters in length, and one and three-quarters millimeters in width. The rounded head is nearly invisible from above, being covered by the prothorax, and the combined length of these two parts nearly equals that of the elytra. The elytra are steep and obliquely concave at the posterior ends, and the outer margin of each bears a set of three prom-

* *Ips plastographus* Lec. and *Ips radiatæ* Hopk. A thesis submitted to the Department of Entomology and the Committee on Graduate Study of the Stanford University in partial fulfillment of the requirements for the degree of Master of Arts in 1915.

† Proc. Ent. Soc. Wash., 17:1-54, (1915).

inent teeth. (Fig. 1). The second tooth is compressed and closely united with the third, and an apical elevated margin extends from the third tooth to the posterior tip of the elytra. (Fig. 2). The pronotal and elytra punctures are fine. The male differs from the female in being mostly lighter brown in color, usually a trifle smaller in size, and having a second marginal tooth of the elytra enlarged and cylindrical in shape. (Fig. 2). This elongated tooth is about twice as long as the other teeth, and is usually obtuse at the extremity. The teeth on the marginal declivity of the female elytra often vary in length, and are occasionally found to be scarcely visible to the naked eye. They are always finer than those of the male. The sculpture of the elytra closely resembles that of *Ips confusus* Lec., but differs in that there are no punctures on the third, fourth, or fifth interspaces, except near the declivity. They are alike, however, in that the interstrial punctures are confused behind. This species, *Ips plastographus* Lec., has also been confused with *Ips integer* Eich., but they can be separated by their distinct host plants and by their geographical range of distribution. *Ips plastographus* Lec. may be easily separated from *Ips radiatæ* Hopk. by the following characters: seven rows of conspicuous elytral punctures, male with the second marginal tooth the longest, while the marginal teeth of the female are of about the same length, tibia rather slender, tibial spurs nearly evenly distributed, tarsus well developed, and the parent gallery of an inverted Y-shape. (Fig. 5). *Ips radiatæ* Hopk. has the following characters: eleven conspicuous rows of elytral punctures, both sexes with the third marginal tooth the longest, tibia stout, tarsus of medium size, and the parent gallery crescent-shaped. (Fig. 7).

DISTRIBUTION.

The range of this engraver beetle is not limited to the distribution of the Monterey pine (*Pinus radiata* Doug.) which is unique in its sea coast habitat, but has been recorded from lodgepole pine (*Pinus murrayana* Balf.) in the Sierras. This beetle has not been recorded to date as attacking Monterey pine south of the Monterey peninsula or north of Berkeley, California, but will probably be recorded from the entire range of this tree within a few years. The largest natural forest of the Monterey pine is located on the Monterey peninsula but it is also found in small stands on Santa Rosa, Santa Cruz and Guadelupe Islands off the California coast, and a third small tract occurs near the coast in San Luis Obispo County. This tree is used for coarse lumber within these ranges and its ability to grow well in either sandy or heavy soils, where moisture is moderately abundant, makes it very desirable for windbreaks and ornamental purposes throughout all central California.

FOOD PLANTS, NATURE OF INFESTATION, AND HABITS.

This beetle probably will not become a serious pest of fast growing, healthy trees, as it prefers trees which have been injured or weakened by fire, windfalls, the fungus *Cronartium cerebrum* Brond (Peridermium harknessi Bud.); or by such insects as *Dendroctonus valens* Lec., *Diplosis pini-radiatæ* Snow and an undescribed species of twig infesting Pityophthorus. Healthy trees cut for commercial use are soon attacked by this beetle and afford excellent breeding places. Shortly after the pine trees have been injured the beetles seem to be attracted, possibly by some odor produced by the condition of the sap, and attack the tree in countless numbers. The adults fly about mostly in the early evenings, avoiding the intense heat of the day. Only during the rainy season is there any degree of cessation in these attacks, and a few warm days bring the adults out again in small numbers to attack other trees. In one instance, where healthy trees were cut for firewood, the beetles were observed to have started galleries within two days.

The adult beetles are more numerous through September, October, and November, during which time they appear in swarms. The male beetle in most cases, starts the new gallery in a crevice or where the bark has been injured, and within a day the females enter the gallery as if led by some natural instinct. Not more than three females were observed to enter a single gallery, and the number was often less. Each female begins to make her individual gallery, all burrowing parallel with the grain of the wood, one going upward and two downward so as to make a combined gallery the shape of an inverted Y. While the females are cutting through the tender cambium, just scarring the sapwood, the male cuts a nuptial chamber to one side of the entrance hole. The male is usually found in this chamber protecting the females from invading enemies and other males while he removes the cuttings as worked toward the hole by the females. The cuttings are collected together, by the use of the legs, and are then pushed out of the entrance hole by using the declivity of the elytra as sort of shovel. The females cut egg pockets on both sides of their respective galleries as the gallery is being extended. These pockets are never closer to one another than half a millimeter, but may be any greater distance apart according to the proximity of dry cambium or

other parent galleries. These beetles seem to have a sense which teaches them not to place eggs on a side of their gallery which is near an adjacent gallery, as the intervening amount of cambium would not be sufficient for the usual number of larvæ. The length of the parent gallery varies according to the season, but averages about 110 millimeters. The width varies from three to three and a half millimeters, while the egg pockets as cut by the females, are one to one and a half millimeters deep and the same in width. After cutting these notches, the female deposits one egg, and then withdraws to collect some tender cambium cuttings which were removed in making the pocket. The female packs these cuttings into the egg pocket in the same manner as the male pushes cuttings out of the entrance hole.

The larvæ on hatching, feed on a small portion of the tender cuttings in the egg pocket, and then begin to cut individual mines at right angles to the parent gallery. The larval mines increase in size with the increasing age of the larvæ, and when the egg pockets are close together the larvæ eat practically all of the cambium, undermine the bark, and pack the old part of the mines with cuttings and excreta, (Fig. 6). When the larvæ are mature they construct pupal chambers, which average about seven millimeters long by four millimeters wide, at the end of the mine. The combined length of a mine seldom exceeds forty millimeters, but the beetles are often so abundant that the larvæ destroy all the cambium on the trunk and larger limbs in a very short time. During the rainy season the larvæ, pupæ and adults remain dormant, except, during the warmest days and in early spring, when they renew their activities. All adults avoid small branches in making galleries, probably because the moisture content of these branches would not be sufficient to carry the larvæ through to maturity. Likewise the larvæ avoid all dry cambium in making their mines.

LIFE HISTORY.

Egg.—Copulation was only observed to occur in the nuptial chamber of the gallery, and the female began laying eggs within half a day. These eggs are slightly oblong, rounded at the ends, pearly white, shiny, three-quarters of a millimeter long, and three-fifths of a millimeter wide at the broadest part. The total number of eggs laid by each female varies in the season, most being laid during the warm days of the summer and none during the winter. The number of females observed laid an average of sixty eggs apiece while the maximum number

laid was 104. The eggs hatch in about four days, but the length of time varieswith the temperature. The life cycles observed extended through the latter part of September, until the early part of October, when the beetles were present in numbers and the temperature was moderate.

Larvæ.—When the larvæ hatch, the head is the most conspicuous part, the body is whitish in color, cylindrical, footless, averaging 1.05 mm. long, with head 0.60 mm. wide and thorax 0.45 mm. wide. As they grow older, they become stouter, more yellowish-white in color, and the body deeply but closely wrinkled. When but five days old hairs begin to appear on the dorsal side of the head and on the last three segments, the mandibles become darker in color and shiny, the larvæ are 1.80 mm. long, head 0.65 mm. wide, thorax 0.70 mm. wide and the larval mines average 19 mm. in length. By the tenth day the larvæ begin the construction of the pupal chambers, and in three weeks the mature larvæ lie dormant in the chambers awaiting transformation into pupæ when the larvæ are 4.50 mm. long, head 0.90 mm. wide, thorax 1.50 mm. wide and the larval mines average 40 mm. in length. When the brood has started late in the fall, many larvæ lie dormant through the cold rainy season, to become active again as soon as favorable temperature arrives in the spring.

Pupæ.—The pupæ are fully developed by the early part of the fourth week and they are of the same general color as the mature larvæ, with more of the general form and size of the adult, the leg and wind pads folded beneath the body, the abdominal segments exposed and averaging 5.20 mm. long, head 1.00 mm. wide and thorax 1.60 mm. wide. The ninth segment bears two prominent fleshy spines and the other segments have more or less well developed dorsal, lateral and pleural spine-like protuberances. The wing pads are nearly smooth, except for a few faint impressions marking the future rows of elytral punctures. Many pupæ, which transform late in the fall, lie dormant through the rainy season and transform to adults on the appearance of warm spring weather.

Adult.—The pupæ usually transform into adults by the end of the fifth week. The young beetles are yellowish-slate in color, with head, eyes and posterior tip of the elytra light brown in color. This brown color spreads rapidly over the entire beetle and by the sixth week, the beetles have attained their natural dark brown to black color, are 5.00 mm. long, head 1.30 mm. wide and thorax 1.70 mm. wide. The majority of the adults remain under the bark for protection during the cold rainy months to emerge during the first warm weather in the spring. Those adults which begin new galleries in the late fall, resume their activities in the spring. Soon after the females have finished egg-laying they crawl out of the gallery and die. The young beetles which have remained in their pupal chambers over winter escape by cutting a hole directly out through the bark, and immediately seek a new host. The largest summer brood appears in August and September, and swarms of the adults attack the freshly cut timber or weakened trees.

CONTROL.

A. *Natural Enemies.*—Among the predaceous enemies we find two species of Clerid beetles, which are of much importance, namely: *Clerus sphegeus* Fab. and *C. nigroventris* Lec. The beetles are voracious feeders and kill many adults. A species of Trogositidæ, (*Trog. virescens* Fab.) was observed to kill many of the young Ips. Larvæ of Raphididæ were found in the pupal chambers of Ips in large numbers where they were observed to have eaten both the larvæ and pupæ. A small species of Cucujidæ was found in several parent galleries, and in all cases the adult Ips were absent, but the writer could not determine whether the Ips had been killed or driven out. Two species of Braconidæ were found ovipositing in wood which was heavily infested with Ips, but it was not conclusively demonstrated that they were primary parasites of Ips. A small grayish mite with a light band across the dorsal side of the abdomen belonging to the family Tyroglyphidæ was found to be the most important enemy. The adult mites were often taken under the wings of the Ips and after the female Ips had deposited her eggs the mites crawled into the egg pockets. Here they would lay a number of minute pearly white eggs on those of the Ips. The young mites on hatching from these eggs would suck the contents from the Ips eggs and thus destroy them. In a few cases it was observed that when Ips eggs were not plentiful, a number of the mites would attack young larvæ and kill them.

Fungi played an important role in killing larvæ, pupæ and adults; especially during the rainy season. The herbarium mold (*Erotium herbariorum*) was observed to have killed many larvæ, pupæ and adults by suffocation. A species of Penicillium and one of Aspergillus were also observed to kill numbers of Ips, but in fewer quantities than by the herbarium mold.

During the heavy winter rains the water often soaked the cambium, which has been mined by the Ips, and many larvæ, pupæ and young beetles would be drowned.

B. *Artificial Means.*—In order to protect trees from future attacks of *Ips plastographus* Lec., all infested trees should be cut for wood, utilized immediately and the slashings burned. Dense stands of timber should be thinned out in order to permit the healthy trees to combat the injury done by weakening

insects and fungi. Windfalls and all unhealthy trees should be disposed of during the dormant season. If these methods are closely followed this injurious beetle can be reduced in numbers and practically exterminated in any locality.

It has been found that healthy Monterey pines can withstand the attacks of *Dendroctonus valens* better than those trees growing in a close stand. This has been proven on the Stanford estate, where trees injured by this species of Dendroctonus and trees which had been injured by fire become breeding places for Ipidæ and died in a relative short time.

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PART II.—*Ips Radiatæ*.

DESCRIPTION.

The general characters of this species are not unlike those of *Ips plastographus* Lec., but differ in that the declivity is a trifle more oblique, the number of rows of elytral punctures is greater, the strial punctures not distinctly coarser than those of the interspace, tibia stouter, and the tarsus not as stout.

The male differs from the female in having the coarse marginal teeth bent inward, and a small protuberance at the lateral base of the most prominent tooth on each margin. (Fig. 4). The males are usually darker in color, mostly smaller in size, and show a more regular arrangement of elytral punctures.

This species has been confused with *Ips* (Tomicus) *concinnus* Mann. but may be distinguished from it by a more reddish color and the much coarser pronotal and elytral punctures. The distribution of host plants is also distinct, in that *Ips concinnus* Mann. attacks Sitka spruce (*Picea sitchensis* Bong.) from northern California to Alaska. While *Ips radiatæ* only attacks Monterey pine (*Pinus radiata* Doug.) and lodgepole pine (*Pinus Murrayana* Balf.).

DISTRIBUTION.

In California *Ips radiatæ* attacks Monterey pine in the central coastal region and lodgepole pine in the higher Sierra Nevada Mountains, extending with this latter host as far north as Priest Lake, Idaho.

FOOD PLANTS, NATURE OF INFESTATION, AND HABITS.

The food plants and nature of infestation or injury are similar to those of *Ips plastographus* Lec., but differ in that the adult of this species cuts a crescent-shaped gallery (Fig. 7), lays four eggs in each egg-pocket, and the number of females in a gallery is apparently less definite—usually two. In the latter case each female usually cuts a gallery in the opposite direction from the other, making a combined S-shaped gallery. The egg pockets, two to two and a half millimeters deep, one and a half to two millimeters wide, and a half mm. apart, are nearly all cut on the outside bend of the gallery, so that the young larvæ will not interfere with one another in procuring enough food to last them through their larval stage. The larvæ cut their galleries or mines directly out from the parent gallery, and when parent galleries are close together the intervening cambium is destroyed. The combined single parent gallery, with the numerous larval mines, well illustrates the name "engraver" beetle by making the fantastic fan-shaped engraving on the sapwood (Fig. 8). When galleries of both species of Ips are found intermingled under the same piece of bark they can be easily differentiated by the peculiar shape of the parent galleries.

LIFE HISTORY.

A. *Egg.*—Copulation was observed to occur only in the nuptial chamber and the female started to lay eggs within a few hours. The eggs are oblong, with blunt rounded ends, shiny, pearly-white in color, 0.75 mm. long and 0.65 mm. in diameter. These eggs, four to a pocket, are placed with their long axis parallel with the grain of the wood when possible. Each female lays an average of about ninety eggs, with the maximum number observed of 176.

B. *Larvæ.*—The young, hatching out in about four days, have conspicuous large heads, with white body cylindrical in shape, 1.05 mm. long, head 0.40 mm. wide and thorax 0.40 mm. wide. They soon grow stouter and more yellowish-white in color, with body deep, but closely wrinkled. In about ten days the head and mandibles become shiny and darker in color, when the body is 3.10 mm. long, head 0.90 mm. wide and the larval mines average 57 mm. in length. By the fourth

week small hairs appear on the dorsal side of the head and on the three last segments, the body is 4.30 mm. long, the head 1.20 mm. wide and the larval mines average 87 mm. in length. During the sixth week the mature larvæ begin making their future pupal chambers, while the seventh week finds them at rest awaiting transformation into pupæ when the body has reached 7.25 mm. in length, the head 1.20 mm. wide and the larval mines average 1.20 mm. in length. Many larvæ, hatching out late in the fall, lie dormant during the cold rainy season. The length of time required for the larvæ to become mature is almost double that required by the larvæ of *Ips plastographus* Lec.

C. *Pupæ.*—The larvæ pupate in the early part of the eighth week, and appear similar to those of *Ips pastographus* Lec. except that the future rows of elytral punctures on the wing-pads are represented by more depressed lines. The pupal chambers average seven by five mm. and are lined with cuttings. A few pupæ lie dormant over the winter, rainy season.

D. *Adult.*—The young beetles appear in the ninth week and resemble those of *Ips plastographus* Lec., except for the third prominent marginal tooth. Very few adults mature before the winter rains begin, hibernating in their pupal chambers until warm weather returns, when they bore directly out through the bark. The adults immediately seek a new host and begin the summer broods. The parent galleries average sixty-five millimeters long and two and a half to three millimeters wide. Both sexes appear to be very timid and more easily excited than *Ips plastographus* Lec.

CONTROL.

A. *Natural Enemies.*—The natural enemies of *Ips plastographus* Lec. also kill this species in the same manner and numbers. A pink *Penicillium* fungus was found only on this species and it appeared to kill large numbers of the Ips in all stages of development.

B. *Artificial Means.*—The same as proposed for *Ips plastographus* Lec. apply to this species.

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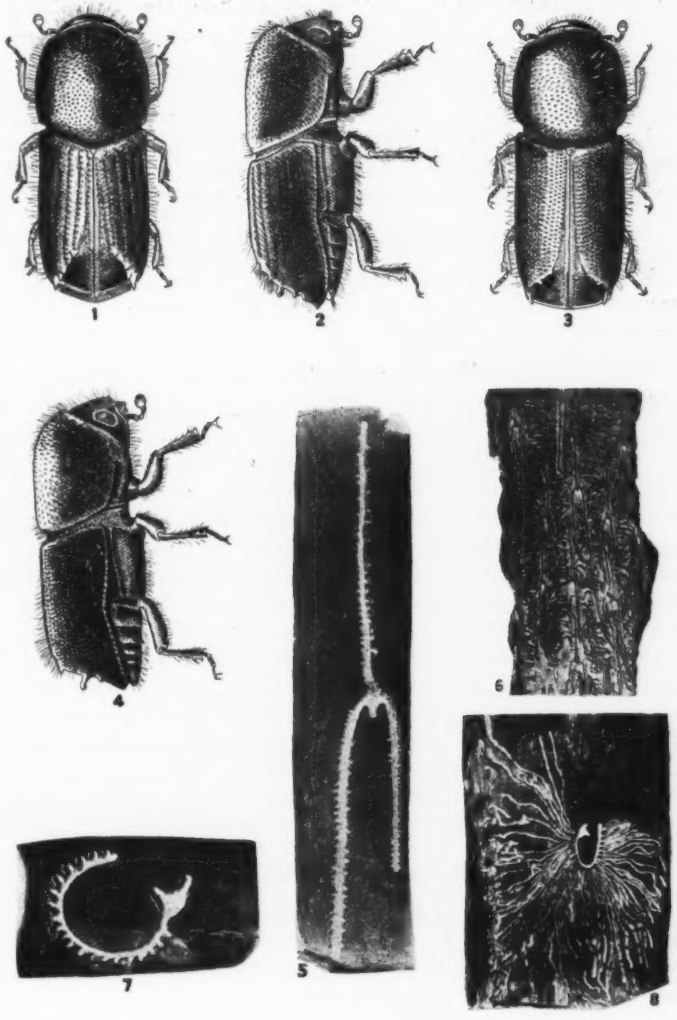
EXPLANATION OF PLATE XL.

Fig. 1. Dorsal aspect of adult female *Ips plastographus* Lec.
Fig. 2. Lateral aspect of adult male *Ips plastographus* Lec.
Fig. 3. Dorsal aspect of adult female *Ips radiatæ* Hopk.
Fig. 4. Lateral aspect of adult male *Ips radiatæ* Hopk.
Fig. 5. Parent gallery of *Ips plastographus* Lec.
Fig. 6. Bark of Monterey pine undermined by *Ips plastographus* Lec.
Fig. 7. Parent gallery of *Ips radiatæ* Hopk.
Fig. 8. Complete gallery of *Ips radiatæ* Hopk.

(Original photographs).



F. M. Trimble.

BEES FROM THE TONGA AND SAMOA ISLANDS.

By T. D. A. Cockerell,
Boulder, Colorado.

During July, 1924, Mrs. Cockerell visited the Tonga and Samoa Islands, and the collection of bees obtained by her, though small, is of more than ordinary interest.

Apis mellifera Linnaeus.

Workers from Nukualofa, Tonga; abdomen black, in one example red at sides of base of second segment. Of course introduced.

Megachile scutellata Smith.

Nukualofa, Tonga, 10 ♀, 1 ♂; Vavau, Tonga, 1 ♂. In the British Museum I found 17 specimens from the Fiji Islands, and noted as follows: "Easily known by the remarkable conical scutellum; shining black insects with brilliant red ventral scopa, black on last two segments; two pale spots of hair in scutello-mesothoracic suture." F. Smith described it from the "South Sea Islands." My specimens (♀) have the hair on the tarsi darker than Smith indicates, on the hind tarsi almost or quite black. The male has short inconspicuous spines on the anterior coxæ. Both sexes were described by Friese in 1911 as *M. fimbriventris*, his material being from the Fiji and Tonga Islands. He overlooked the conical scutellum. Meade-Waldo, in the British Museum collection, had recognized this synonymy. *M. pictiventris* Sm., from Australia, with which Friese compares his species, is only superficially similar, and has an ordinary scutellum.

Megachile wilmattæ n. sp.

Apia, Samoa, 7 ♀, 5 ♂, (*Wilmatte P. Cockerell*).

Closely related to *M. scutellata*, with the same shining surface and red scopa, as well as the conical scutellum, but much smaller, and otherwise differing thus:

♂. Length about 9 mm.; light hairs of face strongly suffused with reddish; abdominal hair bands clear ferruginous, and much broader at sides; ventral scopa black only on last segment.

♂. Length 7 to 8 mm.; anterior coxæ simple; abdominal bands red, and broad at sides. Both species have abundant red hair, like the scopa of female, on under side of male abdomen.

The differential characters, though comparatively slight, are quite constant, and there is no doubt that the Samoan insect is a distinct species.

Megachile vavauensis n. sp.

Vavau, Tonga Is., 1 ♂.

♂. Length nearly 10 mm.; at first sight similar to *M. scutellata*, but very easily separated as follows: Clypeus and region between and below antennæ densely covered with long ochreous hair, but sides of face with long black hair; eyes dark purplish; cheeks narrower; mesothorax and scutellum dull, finely rugose; light hair-marks between mesothorax and scutellum much reduced; scutellum only feebly gibbous in middle (scutellum and disc of mesothorax with long black hair); second cubital cell shorter, receiving second recurrent nervure much nearer its end; anterior tarsi with a fringe of white hair behind, middle tarsi behind and hind ones beneath, with bright red hair; bands on abdominal segments 2 to 4 only present at sides, and very bright deep red, fifth segment covered with red hair; sixth segment more prominently bidentate; ventral segments with only short red fringes, not scopa-like.

A distinct species, but related to *M. doanei* from Tahiti, and *M. calens* Ckll, from the New Hebrides. *M. doanei* is readily known from it by the absence of black hair on scutellum, and long erect tufts of pale hair on front, before the ocelli. The projections on sixth abdominal segment in *M. doanei* are longer and closer together. *M. calens* has a quantity of black hair on scutellum, but the apical teeth on abdomen (sixth segment) are much longer and sharper, and the cheeks are broader. *M. calens* also lacks the conspicuous red hair on middle and hind tarsi, and there is less black hair at sides of face. The disc of mesopleura is black haired in *M. vavauensis*.

Lithurgus albofimibriatus Sichel.

Vavau, Tonga Is., 2 ♂; Apia, Samoa, 1 ♀.

Originally described from Tahiti, whence I have specimens. It has been introduced into the Hawaiian Islands.

Halictus perpessicius Kohl.

Apia, Samoa, 1 ♀. Described from Upolu, Samoa, but Kohl mentions seeing a specimen from the Fiji Islands.

Halictus stevensoni n. sp.

Apia, Samoa, 2 ♂.

♂. Length about 6.5 mm.; slender, with long black submoniliform antennæ; head and thorax very brilliant blue; abdomen black, faintly purplish; legs long, mainly ferruginous, with the coxæ except apically, base of trochanters, middle femora above and below, and hind femora, except base and apex, as well as the anterior femora behind, dark blue; tegulæ red; wings brownish; stigma very large and black; nervures piceous, outer recurrent and intercubitus weakened, basal nervure falling far short of nervulus; first recurrent meeting second intercubitus a little on outer side; apical plate of abdomen broad and large, concave and apically truncate; maxillary palpi with six subequal joints, the last three slender. Clypeus flattened and highly polished, without evident punctures; front dullish, mesothorax dull in front, shining behind; scutellum shining; area of metathorax with fine longitudinal plicæ, apically thickened, obtuse and shining; posterior truncation rather small, poorly defined above; abdomen with the dorsal sutures depressed.

Named after Robert Louis Stevenson, who spent his last years in the locality where the bees were found.

Related to *H. perpessicius*, but not its male, which has been described by Kohl, and is colored like the female. It is also evidently different from *H. extraordinarius* Kohl, the other known Samoan species.

The bees known from the Samoan and Tongan Islands are few, but it can be said that they are entirely different from those endemic in the Hawaiian Islands. Their affinities are with the species of Tahiti, the Fiji Islands, the New Hebrides, etc. Even so remote an island as Guam has a bee-fauna much more nearly allied to that of the Samoan and Tongan groups, than to that of the Hawaiian Islands. Within the Polynesian area there is evidently considerable local diversification, so that the exploration of additional islands will bring to light numerous new species.

OBSERVATIONS ON THE EARLY LARVAL ACTIVITIES OF NYMPHULA MACULALIS CLEMENS* (LEPIDOPTERA).

By PAUL S. WELCH,
University of Michigan.

In a previous paper dealing with the biology of certain aquatic Lepidoptera, the writer pointed out (1916, pp. 173-174) that while it was possible to force a few first instar larvæ of *Nymphula maculalis* Clemens to feed upon the tissue of the floating, green leaf of the yellow water-lily in small aquaria, the normal field habits of the younger instars were not determined and that in rearing such larvæ in aquaria difficulty was experienced in securing the second larval instar and in preventing a very high mortality among those which hatched from egg-masses. It was also pointed out in the same connection that certain circumstantial evidence suggested that possibly the larvæ, on hatching, "settle to the bottom and after one or two ecdyses, approach the surface of the water on the petioles of the water-lily." Field observations and breeding work in aquaria subsequent to that on which the above mentioned paper was based repeatedly confirmed the following points from which the inference concerning some form of bottom life for early instars was derived: (1) Recently hatched larvæ tend to drop to the bottom of aquaria and wander restlessly about, manifesting no interest in fresh tissue from floating leaves of the normal food plant (2) The first and second instars are not found, in the field, on the floating leaves of the yellow water-lily, although such leaves are the bearers of the egg-masses; (3) Only well advanced larvæ occur on the floating leaves, but somewhat younger larvæ are to be found on the submerged, gréen leaves which have not yet reached the surface; and (4) Pupæ are absent on submerged leaves. It therefore became reasonably certain that a study of the bottom of the lily beds was necessary in order to understand the early larval development of this species. Forbes (1910, p. 225) had also reported that in his work on *Nymphula gyralis* Hulst the larvæ, just hatched from the

* Contribution from the University of Michigan Biological Station and from the Zoological Laboratory of the University of Michigan.

eggs, "all died without eating, though provided with leaves of Nymphaea and Limnanthemum (laid on the latter), but they gathered on the Nymphaea leaf in numbers. Possibly in the first stage they may feed on the submerged stems." Apparently circumstances attending the early larval history of *Nymphula gyralis* resemble somewhat those of *Nymphula maculalis*, and it may be that results described herein will yield some clue as to their nature.

During the summer of 1923, the writer undertook the solution of these unknown problems concerning early larval life and the following results obtained answer, at least in part, the questions concerning the nature of the bottom-living period and subsequent activities leading to the later, surface dwelling stage. During the summer months both the food plant and the insect in question occur in certain portions of Douglas Lake, Michigan, in such abundance that there is never lack of material on which to make observations and experiments, and all results described herein were verified over and over again.

FOOD PLANT.

Certain structural features of the yellow water-lily are intimately involved in the early larval activities and therefore deserve comment here. In one or two of the protected bays of Douglas Lake this plant occurs in beds, practically unmixed with other aquatic plants. In adjacent situations it is abundant but intermingled with the white water-lily (*Castalia odorata*), and several larger aquatic plants.

Identity.—Only one species of yellow water-lily occurs in Douglas Lake. Its identity seems to involve some confusion as to the species name. In Britton and Brown's Illustrated Flora this plant is called *Nymphaea advena* (Soland); in Gray's Manual of Botany it is included under *Nymphaea advena* Ait.; while in Miller and Standley's (1912) extensive work on the North American Species of Nymphaea, the name *Nymphaea americana* (Provancher) is applied to the Douglas Lake form. Since the writer has used the name *N. americana* in his previous publications, that name will be retained in this paper.

General Structure.—As it grows in Douglas Lake, the yellow water-lily presents four general structures which may serve as food, at some time, for the larvæ of *N. maculalis*, namely, (1) floating leaves; (2) submerged, rolled up leaves,

which ultimately become floating; (3) true submerged leaves, which never become floating; and (4) the flower stalk. The features of the floating leaves, the temporarily submerged leaves, and the flower stalk are too well known to require comment. The *true submerged leaves*, however, necessitate discussion. They arise at the periphery of the cluster of those petioles which extend to the water surface, thus surrounding them closely at their bases. The petioles of these submerged leaves are so reduced in length that the leaves rest wholly or in part upon the bottom. In fact, their prostrate position on the bottom often results in their partial burial in the finer bottom materials. They are completely expanded, with their concave upper sides directed towards the water surface, thus covering an area of the bottom which, depending upon the size of the whole cluster to which they belong, may vary from approximately five to eighteen inches in diameter, and frequently touch the similar leaves in adjacent clusters. In the thickest portions of the lily beds the bottom is largely covered in this way. These leaves differ strikingly from the floating green ones in (a) their predominating reddish color; (b) the very thin, delicate nature of the whole leaf, particularly the marginal portions; (c) the wavy character of thin margins; (d) the broader shape of the leaf; and (e) the absence of stomata. It is likely, also, that these leaves are not cutinized.

Miller and Standley (p. 78) state that the submerged leaves are "sometimes but not always present." They were invariably present in the lily beds in Douglas Lake in 1923.

DESCENT TO BOTTOM.

On hatching, the young larvæ manifest continued activity from the moment of hatching, and while the actual initial sinking to the bottom was not observed in the field, their behavior in aquaria and the finding of numberless larvæ of the first instar exclusively on the bottom in the field indicate that they settle through the water immediately on hatching. Experiments showed that they sink slowly in quiet water. Not the slightest evidence of any ability to swim was observed. In spite of the fact that great numbers of these young larvæ occur at the bottom, the descent must be accompanied by considerable hazards since they are quite subject to movements in the water. In Douglas Lake the lily beds occur

largely at or near the brink of the steep "drop off" and it seems almost certain that many of the tiny larvæ must be swept over the brink into deep water. Also waves coming towards shore would doubtless sweep many larvæ entirely out of the lily zone. The crawling ability of the tiny larvæ is so ineffective that either of the above mentioned exigencies would most likely be insurmountable. The coincidence of hatching and rough water must be productive of a large mortality, even though the mass effect of the vegetation bed may tend to reduce somewhat the water movement. It is possible, however, that water movements may be responsible for a wider dissemination of the larvæ on the bottom than would otherwise occur.

BOTTOM ACTIVITIES.

Method of Study.—Since one of the most favorable situations existed in water varying from one to two and one-half feet deep, it was possible to make a critical and intensive study of the bottom activities of the early instars by means of the glass bottom pail. At times of complete calm and clear sky the extremely clear water made this device almost unnecessary.

Case Making.—Every evidence indicates that when the tiny larvæ sink from the egg-masses on the floating leaves, the outspread surfaces of the red submerged leaves beneath offer immediate lodgment for many and those less fortunate ones which drop to the sand nearby may be able to crawl upon them. At any event, the evidence is conclusive that the red submerged leaves constitute the first food and the first materials for case making. Experiments performed both in the laboratory and the field showed that a larva just hatched, when placed in water upon a red leaf immediately and invariably began eating and initiating the formation of a diminutive case of the characteristic sort. The case cuttings of the tiny larvæ are at first almost always on the thin tender edge of the leaf, ultimately giving it a crenate appearance. The length of the case cutting at this period is about one and one-half millimeters. Somewhat rarely cuttings are made remote from the margin, resulting in a small hole through the leaf. Occasionally the cuttings of several larvæ working simultaneously become confluent, and result in the detachment of a much larger piece either from the margin or the middle of the leaf. The same effect may also be caused by several larvæ cutting in succession from the same edge.

If the larvæ are present in considerable numbers the case cutting may result in the destruction of much plant tissue. In one lily bed the writer found, on July 31, every cluster of the red submerged leaves mutilated by such cuttings and in some cases the whole leaf had been reduced to nothing but the short petiole.

Repeated scrutiny of bottom materials and other bottom plants underlying the floating lily leaves disclosed no larvæ at any time during the season. It therefore seems certain that the red submerged leaves, representing as they do a different type of structure from the floating green leaves, are the normal and exclusive food of the larvæ during the earliest instars, and the reason for the difficulties experienced by the writer in his earlier work in trying to rear them on the tissue from the green floating leaves is now obvious. In fact, the breeding of the tiny larvæ in aquaria was effected during the past summer with perfect ease by the use of the red leaves.

Whether the duration of the bottom inhabiting period is a definitely fixed one remains to be determined. Examinations of a large number of the cases showed caterpillars representing the first two larval instars and so few of the third instar that it might be inferred that the end of the second larval instar marked the approximate conclusion of bottom existence. During the progress of this study an occasional caterpillar, nearly mature, was found at the bottom, but the writer believes that such instances were the results of accident, since it is easily demonstrated that larvæ of any age, detached from their cases, sink to the bottom. Most observations of this kind were made shortly after the occurrence of severe wave action.

MIGRATION TO SURFACE.

At the completion of the bottom-inhabiting period the larvæ begin a migration to the surface of the water to become feeders upon the green floating leaves. This migration is accomplished by two means, with possibly an occasional combination of both, namely, the *flotation method* and the *petiole method*.

Flotation Method.—This method consists essentially of a release from bottom attachment with subsequent flotation to the surface due to the buoyancy of the lens-shaped case. As stated before, larvæ isolated from cases sink, but the case itself

is lighter than water and when detached will slowly but regularly rise to the surface, carrying in addition the weight of the included larva. Whether the release at the bottom is a deliberate one on the part of the larva is not known. In a limited number of instances observed the release was accidental, since the cutting of the young larvæ on the red leaves sometimes inadvertently released larger, irregular pieces bearing other larvæ, and the whole group floated to the surface together. Such accidents, of course, occasionally resulted in the premature transportation of some very young larvæ to the surface.

Field experiments were performed in which larvæ of about the second instar were gently released at the bottom and the results carefully observed. The cases invariably floated to the surface, unless they became temporarily lodged in a tangle of submerged vegetation. Shortly after flotation begins, the tiny larva extends the anterior one-fourth to one-third of the body beyond the margins of the case and performs exploratory movements, retreating intermittently into the case. This behavior may result in an interruption of the journey if the exploring legs of the larva come into contact with vegetation. If, however, no parts of vegetation are interposed the case soon arrives at the top and floats *at the surface*, but not on it.

Petiole Method.—Small larvæ in red cases may be found attached to the petioles of floating leaves anywhere along their entire length and their feeding activities result in irregular troughs about one-half a millimeter deep and of varying length. The same is true of the petioles and rolled up leaves of the submerged, partly developed green leaves, except that the feeding activities are such that when the partly rolled-up leaf unfolds each feeding area results in a set of transverse holes. The submerged flower stalk is also subject to attack, both on the stalk proper and on the bulbous top, and considerable injury may result to the undeveloped flower before it has an opportunity to reach the surface and bloom.

The red cases, attached at various depths, and usually held edgewise to the support and not infrequently are made additionally secure in position by a few silk strands.

TRANSITION TO SURFACE LIFE.

When a case arrives at the surface, the larva usually remains quiet for a time. During this interval the cases float about

easily at the will of the wind and water movements. The characteristic upturned leaf margins of *Nymphaea americana* make it easy for the cases with their closely opposed edges to drift well under the floating leaves. The enclosed larva then manifests exploratory movements with the anterior end of the body, grasps the leaf with its legs and quickly draws the case completely under. In time the red cases are deserted for new ones made from the floating leaves in a fashion already described in an earlier paper (Welch, 1916, pp. 170-173), but the red parts are often retained for a time at the edge of the green ones and sometimes in the transition a case may be observed with one-half composed of the original red material and the other of a fresh green piece of recent origin. During times of calm, contact of the recently ascended case with the food plant may be effected by the peculiar but rather inefficient form of case propulsion already described, (1916, p. 172).

DISCUSSION.

How common the bottom inhabiting period is among the other *Nymphula* species remains to be determined. It is, however, suggested by the previously mentioned experience of Forbes with *Nymphula gyralis*. Obviously a bottom existence of any duration would involve a food relation to some basal portion of the surface food plant or to some entirely different submerged plant. It is inferred that no substance other than living plant tissue can serve as food for the various caterpillars of the genus *Nymphula*.

The previously mentioned statement by Miller and Standley that the true submerged leaves of *Nymphaea americana* are not always present results in uncertainty as to whether it is intended to mean that under some circumstances no such leaves are produced at any time during the growing season, or whether it means that they are absent due to earlier disappearance. Professor G. E. Nichols informs the writer that, in his opinion, these submerged leaves, under usual conditions of growth, always develop in spring before the floating leaves and that if at any later time they are absent, as frequently is the case, such absence is due to their destruction by various exigencies of the environment. It is certainly true that the work of the larvæ of *Nymphula maculalis* alone may, at times, completely destroy such leaves early in the season, or so mutilate them

that they are subject to rapid deterioration from other causes. Since it appears that there are at least two generations of larvæ, in the Douglas Lake situation, the question is at once raised as to whether the caterpillars of *Nymphula maculalis* can complete their life cycle in the absence of submerged red leaves. It would appear that in such an exigency, case making at the bottom would be impossible as no material of the usual sort is available. Whether their limited ability to feed upon the bases of the petioles would enable them, as unprotected larvæ, to survive and ultimately crawl to the floating leaves is not known. It seems certain that occasionally those larvæ which appear late in the summer find the submerged leaf material greatly reduced or wholly absent locally. The answer to these questions must await the results of further work.

SUMMARY.

1. Larvæ of *Nymphula maculalis*, hatching from egg-masses deposited on the lower surface of floating leaves of the yellow water-lily, sink immediately to the bottom.

2. Feeding and case making are immediately begun on the tissues of the tender, basal, red, submerged leaves of *Nymphaea americana*. Approximately the first two larval instars are passed at the bottom in this way.

3. On completion of the early instars, migration to the surface is accomplished, either by release at the bottom and direct flotation to the surface, due to the buoyant quality of the case, or by slow passage up the long petioles of floating leaves, or by combinations of both methods.

4. Arrival at the surface of sufficiently advanced larvæ marks the end of bottom existence and they are thenceforth surface dwellers.

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ON THE LIFE HISTORY AND THE POISON APPARATUS OF THE WHITE FLANNEL MOTH, LAGOA CRISPATA PACKARD.

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University of Arkansas

INTRODUCTION

The white flannel moth, according to Holland, ranges from Massachusetts southward along the coast. According to Riley and Johannsen, the white flannel moth occurs in the Atlantic and Southern United States. The caterpillar, Holland says, feeds on blackberry. As early as 1869 the life history of this species was observed by J. A. Lintner. In the published account there are very complete descriptions of the various stages, of the habits of the larvæ, as well as of the manner of spinning the cocoon. The number of larval instars observed were six. The host plants of the larvæ are given as various species of Quercus, Vaccinium, Pteris aquilina, and other plants. According to Smith, quoted by Felt, the caterpillar "lives on most of the orchard trees and small fruits as well as many other trees and shrubs." Felt lists, in addition to the host plants named above, elm, apple, and raspberry.

In a paper published in 1894, A. S. Packard gives a detailed account of the life history, in which he describes the eggs, the various larval instars, as well as the general larval, pupal, and imaginal characters. Although he describes but six instars, as Lintner has done, he seems somewhat in doubt as to whether there may not be an additional instar between the fifth and sixth. This doubt appears, it seems, chiefly because the older larvæ of the fifth instar had "more long hairs in proportion to the short forked ones."

LIFE HISTORY IN ARKANSAS

The caterpillars of *Lagoa crispata* are rather common in Arkansas and may be seen in considerable numbers feeding on the wild blackberry, as well as on unsprayed apple trees. On other plants they have here not been observed.

Research Paper No. 16. Journal Series. University of Arkansas.

In the fall of 1922, a number of the last instar larvæ were collected, placed in battery jars and fed on apple foliage until they spun up. On June 20 of the following year the first adult, a male, appeared. At the same time there was also a tachinid fly that has been determined by Mr. C. T. Greene as *Archytas aterrima* Devoidy. Lintner and C. V. Riley* observed a tachinid parasite attacking the white flannel moth larvæ, but were unable to secure any adults of the fly.

By June 26, three male moths had appeared and one female was observed on this day. Another female appeared on the following day and on the 28th a pair was observed in the act of copulation. They were sitting side by side on the screen wire, anteriorly somewhat diverging, in the form of an acute triangle.

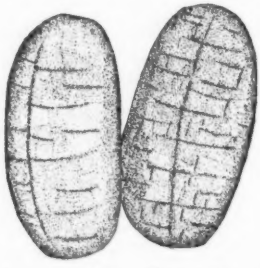

Fig. 1. *Lagoa crispata.* Eggs enlarged 25 times.

The Egg.—On the following day, June 29, a number of egg masses were present. The one shown in the photograph consists of 47 eggs. The total number of eggs was 399. There were three females, but it is not known whether they all laid eggs or not. On July 1 there was an additional female and another egg mass of 20 eggs, making a total of 419 for four females. The eggs began hatching on July 8, when about 50 caterpillars had emerged. The time required for hatching thus is about 9 days.

According to Packard, the eggs appear perfectly smooth, showing even under a 4 mm. objective no polygonal areas. The eggs that I observed presented a pattern of wrinkles (probably of no significance) as shown in Fig. 1. The lines describing polygonal areas are, it seems, very obscure. I was not able to see them.

* Reported by Lintner.

Larval Instars.—The larva during its development passes through seven instars, instead of six, as given by Lintner and Packard. What the latter author took for a change in the fifth instar represents really another instar. As a matter of fact, this instar, the sixth, differs rather strikingly from the fifth, as may be seen by referring to Fig. 2, and Plate XLII, Figs. 7 and 8. The larva in the sixth instar has a very profuse growth of the long hairs and these are arranged in such a bushy formation

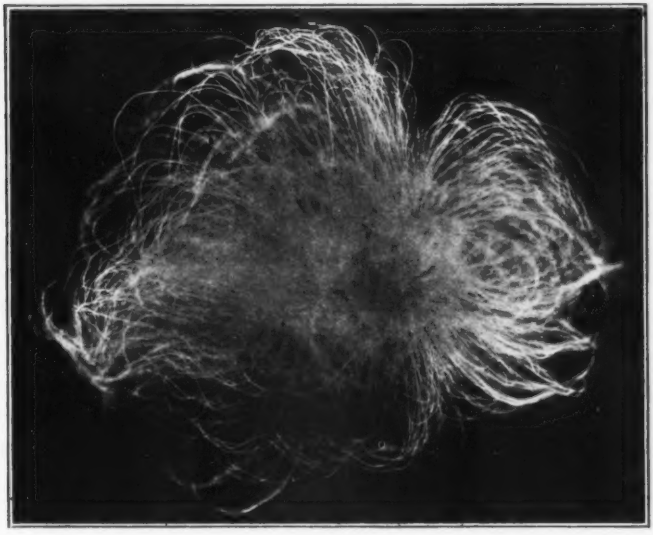

Fig. 2. *Lagoa crispata.* Larva in the sixth instar.

that the creature at first sight has no resemblance to a caterpillar. In the last, or seventh, instar, the larvæ are clothed with shorter and more dense hairs. They vary in color, some being a light brown, while others are gray. The duration of the various stages with corresponding dates is given in table I on the following page.

Limited observations were made in the field where numerous caterpillars were feeding on blackberry. On September 6, practically all of these were still in the sixth instar. It is possible that apple is a more satisfactory food plant, enabling the larvæ to mature from two to three weeks earlier than they do when feeding on blackberry.

TABLE I

	Dates	Number of Days
Appearance of Moths:		
Males	June 20–26	
Females	June 26–30	
Mating	June 28	
Egg laying	June 29–July 1	3
Incubation	June 29–July 8	9
First instar	July 8–12	4
Second instar	July 12–17	5
Third instar	July 17–23	6
Fourth instar	July 23–30 (29–31)	6–8
Fifth instar	July 30–Aug. 7 (Aug. 7 and 8)	8–9
Sixth instar	Aug. 7–13 (Aug. 13–15)	6–8
Seventh instar	Aug. 13–22 (Aug. 22–Sept. 4)	9–12

The table below gives the average length of the caterpillar in the various instars.

TABLE II

Instar	No. Measured	Measurements, in mm.	Average Length, in mm.
First	6	1.40– 2.00	1.7
Second	6	2.50– 3.00	2.18
Third	6	4.25– 5.00	4.7
Fourth	6	7.5 – 8.00	7.6
Fifth	6	9.5 –10.	9.9
Sixth	4	15.	15.
Seventh	2	25. –26.	25.5

The following table gives the width of the epicranial shield and shows that the larva passes through seven instars during its development.

TABLE III

Instar	Width of ep. shield in mm.	No. Measured	Average in mm.
First	.32– .33	6	.326
Second	.43– .46	6	.433
Third	.54– .59	6	.565
Fourth	.96–1.04	6	.999
Fifth	1.24–1.32	4	1.27
Sixth	2.00–2.12	4	2.07
Seventh	2.56–2.60	3	2.58

THE POISON APPARATUS.

In the paper by Lintner already referred to above, he mentions the urticating effect of the larval hairs. He says that from the smaller larvæ only "a slight pricking sensation" is felt. Later the "pricking becomes more acute," followed by a "redness of the skin" and elevated white spots similar to "nettle rash." "The sting is not so severe as that of *Hemileuca maia* or *Hyperchirio* Io." Packard speaks of the hairs as being poisonous, but does not describe the effect. Riley and Johannsen attribute to the poisonous hairs "a marked nettling effect." This effect is described in the same words by Pierce. Martini does not describe the effect of this particular caterpillar, but lists it among a number of species producing "Raupen-urticaria." Phisalix does not refer to this species. From personal observations that I made on a larva of the fourth instar,* it seems that the urticating effect is rather severe and lasting. Merely allowing the inside of the wrist to come in contact with the caterpillar produced a decided reddening of the skin and an appreciable sensation that lasted at least ten hours.

The effect of the poison in the spines of the brown tail moth on the blood has been studied by Dr. E. E. Tyzzer. He found that when placing a poison spine in a drop of blood, the red corpuscles at once become coarsely crenated, and the rouleaux are broken down in the vicinity of the spine.

Repeating this experiment with the poison spines of *L. crispata*, the effects were found to be much as described by Dr. Tyzzer. In addition, it seems to me that the corpuscles break down and as a result a thin film settles on the slide in the neighborhood of the spines. In this film irregular particles may be seen. The film by reflected daylight is whitish with a faint tinge of red.

Although *Lagoa crispata* occurs very commonly in Northwest Arkansas, the urticating effect is apparently quite unknown. That of the Io caterpillar, on the other hand, is a matter of common knowledge.

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* The larvæ have relatively the same urticating effect in all the developmental stages excepting in the first one, from which I could not perceive any pricking sensation.

The Structure of the Poison Apparatus.—Lintner gives a brief description of the "short, slender, acute white bristles directed upward from the several tubercles of the lateral and subdorsal rows. * * * Upon touching the bristles with the hand, they were found to be the source of the sting experienced." Packard has made a somewhat extensive study of the poison apparatus and accompanying his account are a number of drawings. Apparently this work has not been recognized, for Riley and Johannsen say "Satisfactory studies of its poisonous hairs and their glands have not yet been made." Mr. Paul Gilmer, in conversation, stated that among other poisonous caterpillars he had also studied this species and had been unable to confirm the work of Packard.*

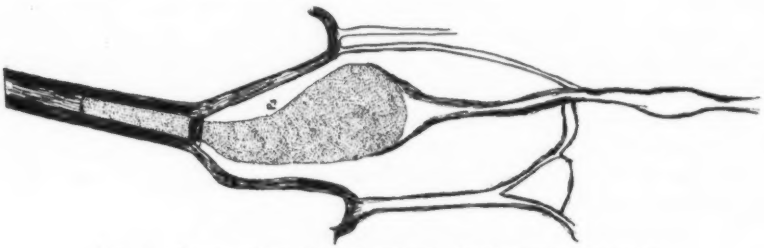

Fig. 3. Cross section through cuticula showing poisonous spine. Ps, poison sac.

Owing to the fact that the poison apparatus apparently has not been satisfactorily studied, it seemed desirable to add this study to that of the life history.

In the late summer of 1922 a number of larvæ of the last instar were secured and after killing in hot water, and fixing in Dietrich's fluid, were preserved in 85% alcohol. During the winter this material was sectioned and stained in several ways† so as to bring out as nearly as possible all the details of the structure. Owing to the fact that the caterpillars, after killing, were merely slit open on the ventral side, the infiltration was rather poor and considerable trouble was encountered in cutting

* So far as I know, Mr. Gilmer's work has not as yet been published.

† The following stains and combinations were used: (In 1922) Dietrich's fixing fluid, Haidenhain's Hematoxylin, Haidenhain's Hem. and Congo Red, Haidenbain's Hem. and Eosin, Delafield's neutral, Delafield's acid, Fleming's Triple, and Saffranin. (In 1923) Zenker's fixing fluid, Haidenhain's Hem., Haidenbain's Hem. and Congo Red, Delafield's, Delafield's and Eosin.

sections. Owing to this, most of the sections were made 15–18 microns thick. The following year, last instar larvæ were again prepared somewhat as before, excepting that Zenker's fluid was used in fixing. Before putting the larvæ

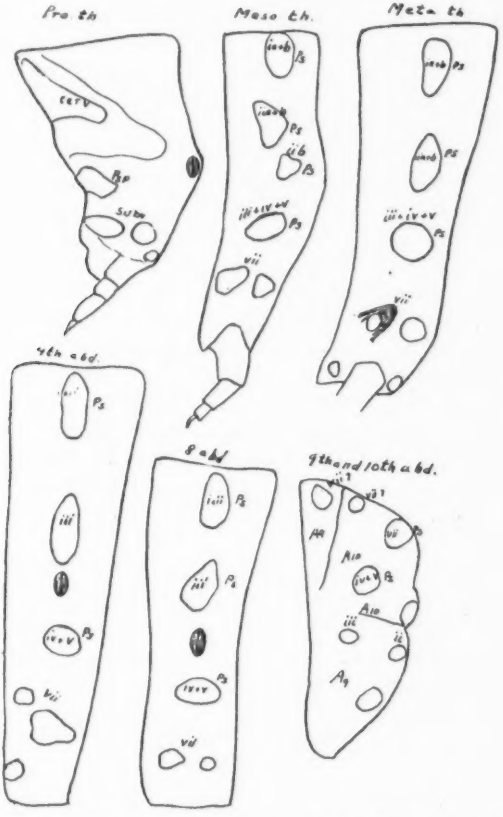

Fig. 4. *Lagoa crispata.* Arrangement of tubercles on the various segments of the body. Ps, poisonous spines.

in the fixing fluid they were slit open nearly all the way along the ventral body wall and the alimentary canal was removed. Following this, there was no difficulty in cutting sections of 10 mm. thickness.

The structure of the poison apparatus as it appeared in these sections differs, it seems, very decidedly from that found in the brown tail moth larva, where certain hypodermal cells are obviously serving as true poison glands. These specialized hypodermal cells are above the general level of the hypodermis, but yet are quite separate from the cuticle. The poison apparatus has also but little in common with that of the white marked Tussock moth. In this species the poison gland cell, apparently a much enlarged hypodermal cell, lies below the general level of the hypodermis.

A structure that is comparable to the poison apparatus in Lagoa has been found in Megalopyga by Foot. Unfortunately, the figure as given by Martini has only a faint suggestion of the hypodermis and no connection is shown between the hypodermis and the poison gland cell.

As may be seen from the drawing in Plate XLIII, and Fig. 3, the structure of the poison apparatus in Lagoa is essentially like that in Megalopyga. The significant feature in each poison spine is the large poison sack (gift sack of Foot) at the base of the spine and lying considerably above the level of the cuticula. The contents of the poison sack are granular and this material extends well up into the poison spine. The poison spines are on an average 6.5 mm. in length, varying from 4.5 mm. to 7.3 mm. The short spines (not poisonous) are about 2.75 mm. in length.

Distribution of Poison Spines.—In the prothorax there are none present, in the mesothorax they are found on tubercules $ia_{+}b$, $iia_{+}b$, iib, and $iii_{+}iv_{+}v$; on the metathorax on $ia_{+}b$, $iia_{+}b$, and $iii_{+}iv_{+}v$; on the first eight abdominal segments, on $i_{+}ii$, iii, and $iv_{+}v$ (dorsal, subdorsal and lateral). On the last, or tenth abdominal segment on vii and $iv_{+}v$ (dorsal and subdorsal.) See Fig. 4. The tubercles bearing poisonous spines are labelled Ps.

All the tubercles on the body, so far as I can determine, present the elongated hypodermal cells, and I fail to see that there are any very specialized hypodermal cells connected with the poison apparatus. The elongated pouch-shaped hypodermal cells found underneath tubercles bearing poisonous spines seem identical to those found under tubercles not bearing any such spines. In all the sections the hypodermis was always more or less removed from the cuticle, and in no case close enough so

that a definite connection could be made out between the poison spine and a certain hypodermal cell. The cuticle underneath the tubercles is in all cases very much thickened and extending through it are the slender ducts leading from the two types of hairs, feathery and spinulate; and the two types of spines, short (not poisonous), and large poisonous spines.

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EXPLANATION OF PLATES.

PLATE XLI

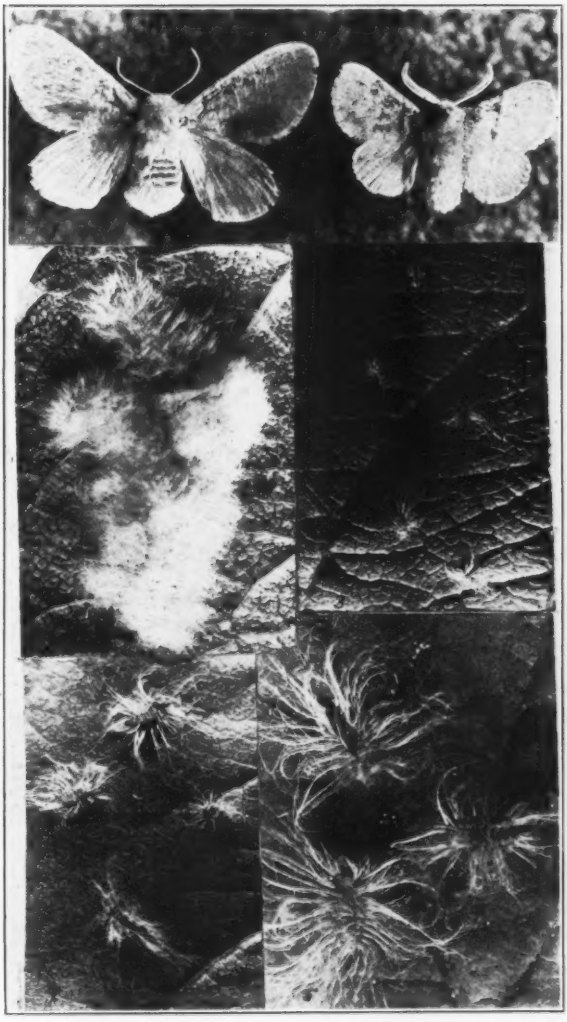
Lagoa crispata. 1, Female and male moths. 2, Eggs with some of the hairs removed. 3, Larvæ in the first instar. 4, Larvæ in the second instar. 5, Larvæ in the third instar.

PLATE XLII

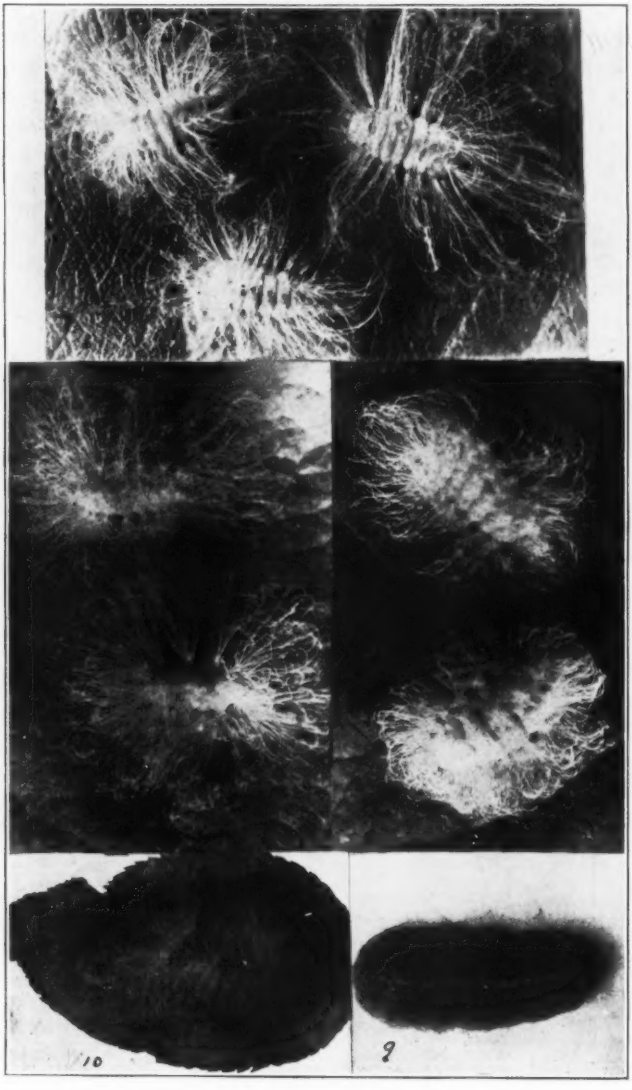
Lagoa crispata. 6, Larvæ in the fourth instar. 7, Larvæ in the fifth instar. 8, Larvæ in the sixth instar. 9, Larvæ in the seventh, or last, instar. 10, Cocoon on leaf of apple.

PLATE XLIII

Lagoa crispata. Diagrammatic section through cuticula and hypodermis, showing feathery and spiny hairs as well as short and long (poisonous) spines. Ps, poison sac.



W. J. Baerg



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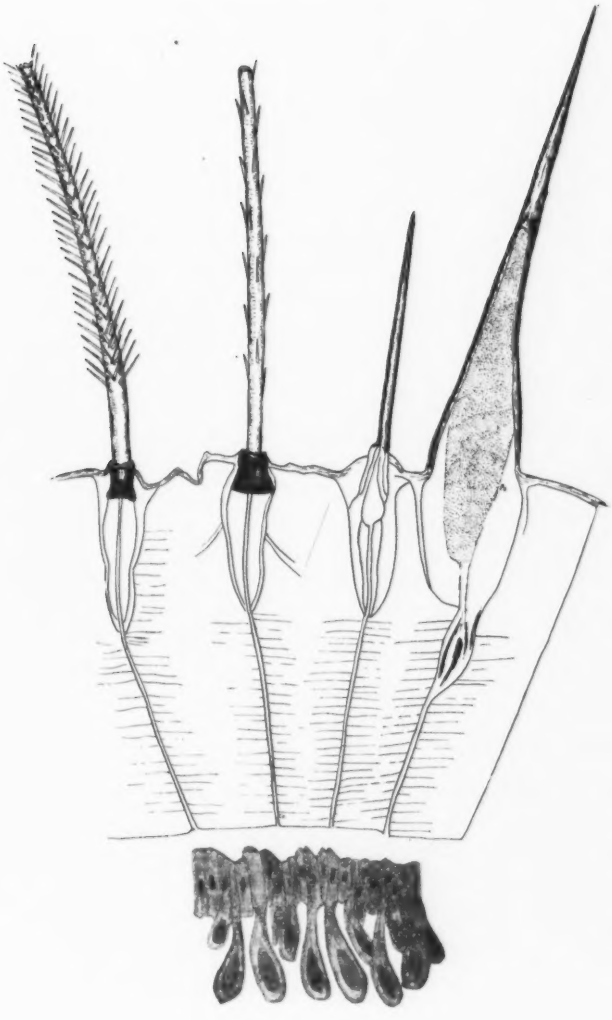

W. J. Baerg

A STUDY OF THE SEGMENTATION OF THE ANTENNAE OF THE CLOVER-FLOWER MIDGE (DASYNEURA LEGUMINICOLA, LINTNER).

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In a letter of January 6, 1920, Dr. E. P. Felt called the attention of the writer to the fact that there is a variation in the number of segments in the antennæ of the clover-flower midge (*Dasyneura leguminicola*, Lintner). Felt (1908) has indicated the range of this variation in a general way as being from fourteen to sixteen segments, inclusive. Felt (1915) p. 174, further states that the female normally has sixteen subsessile antennal segments while the male has sixteen or seventeen antennal segments.

As the writer had a considerable number of reared and collected specimens of *Dasyneura leguminicola*, Lintner, it seemed desirable to make a study of this matter. A total of 115 specimens was studied. Of this number 80 were females and 35 were males. It was found that usually the two antennæ of an individual bear an equal number of segments. However, certain exceptions to this condition were discovered and these will be mentioned later.

Antennæ with all segments distinct, that is, without fused segments or segments showing constrictions.—Of the females whose antennæ had an equal number of distinct segments, 10 had fifteen segments, 48 had sixteen segments and 5 had seventeen segments. Of the males whose antennæ had an equal number of distinct segments, 4 had fifteen segments, 15 had sixteen segments and 2 had seventeen segments, (Summary (a) p. 4).

It was found that one antenna of an individual may bear a different number of segments from the other antenna of the same individual. For example, one male had seventeen segments in the right antenna and sixteen segments in the left antenna. One male and two females had fifteen segments in the right antenna and sixteen segments in the left antenna, (Summary (b), p. 4).

Antennæ having fused segments or segments showing constrictions.—(Only the distinct segments in an antenna were

counted). The distal segment of an antenna may be somewhat constricted indicating the possible differentiation of another segment. A segment of the portion of the antenna proximad to the distal segment may fuse with a segment next to it. Of the 115 specimens studied, 27 showed one or the other of these conditions. Of this number 12 were males and 15 were females. The number of segments in the antennæ of specimens showing the above indicated conditions were counted. Only distinct segments were considered in this connection.

Of the females whose antennæ had an equal number of segments, 1 had fourteen segments, 7 had fifteen segments and 4 had sixteen segments. Of the males whose antennæ had an equal number of segments, 1 had fourteen segments, 1 had fifteen segments and 3 had sixteen segments, (Summary (a), p. 000). Of the individuals whose antennæ had an unequal number of segments, 2 males had seventeen segments in the right antenna and sixteen segments in the left antenna. Two males had sixteen segments in the right antenna and seventeen segments in the left antenna. Three males and one female had fifteen segments in the right antenna and sixteen segments in the left antenna. One female had fourteen segments in the right antenna and fifteen segments in the left antenna. One female had thirteen segments in the right antenna and fifteen segments in the left antenna, (Summary (b), p. 000).

SUMMARY.

Number of Segments in Antennæ of *Dasyneura leguminicola* Lintner.

A. Antennæ with all segments distinct, that is, without fused segments or segments showing constrictions:

(a) Antennæ with an equal number of distinct segments:

Number of Segments	Males	Females
15	4	10
16	15	48
17	2	5

(b) Antennæ with an unequal number of distinct segments:

Number of Segments		Males	Females
Right Antenna	Left Antenna		
17	16	1	0
15	16	1	2

B. Antennæ having fused segments or segments showing constrictions. (Only the distinct segments in an antenna were counted).

(a) Antennæ with an equal number of segments:

Number of Segments	Males	Females
14	1	1
15	1	7
16	3	4

(b) Antennæ with an unequal number of segments:

Number of Segments		Males	Females
Right Antenna	Left Antenna		
17	16	2	0
16	17	2	0
15	16	3	1
14	15	0	1
13	15	0	1

Total number of male specimens..... 35
Total number of female specimens..... 80

Total number of specimens..... 115

CONCLUSIONS.

The number of segments in the antenna of *Dasyneura leguminicola* varied from thirteen to seventeen. The most common number of segments in the antennæ of both sexes was found to be sixteen.

The two antennæ of an individual specimen may have either an equal or an unequal number of segments.

Certain individuals occur in both sexes in which there is a certain lack of definiteness in the segmentation of the antennae. The distal segment may be slightly constricted indicating the beginning of the differentation of another segment. Some of the segments posterior to the distal segments may fuse or be grown together. This is due to the imperfect differentiation of the segments.

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THE LIFE HISTORIES OF THREE SPECIES OF GERRIDS (HETEROPTERA, GERRIDÆ).*

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During the summer of 1923 the writer carried on a number of life history and habit studies, as supplementary work in connection with the evaluation of certain aquatic environments. These studies were made primarily in order to determine the position the various species held in the economy of the environments studied. Since the results of this work will not be published for some time, it has been deemed advisable to publish some of the life histories as separate papers.

When we take into consideration the abundance of water striders to be found in our ponds and streams, it is surprising that the life histories of such a few of them have been recorded. Furthermore it is only within comparatively recent years that we have biological notes on any of our American species.

The Gerrids are not easy to rear for the reason that they do not lend themselves readily to life in captivity. If good sized containers are used and these placed well back on the laboratory table, the specimens are less likely to injure themselves by dashing against the sides. If placed near the edge of the rearing table the striders will be disturbed each time somebody passes. At feeding and observation time the bugs make frantic efforts to escape and in so doing continually butt against the sides of the breeding jar. Observations cannot be made if the rearings are carried on in a large container, unless one has access to a movable-arm binocular.

If an abundance of material is at hand it would be well to preserve the various stages and the descriptions drawn up from these. However, unless many rearings are in progress it is not advisable to kill off too many of the earlier stages for fear none be brought to the adult state. Nymphs that die may be preserved fairly satisfactorily if removed to a preservative soon after their death. Measurements and color markings of these

* Published with the approval of the Director as Paper No. 482 of the Journal Series of the Minnesota Agricultural Experiment Station.

nymphs, however, may not be as accurate as those of healthy specimens killed and placed immediately into preserving fluid.

The rearing methods were essentially the same for the three species discussed in this paper. Jelly glasses were used for the most part as containers, while the food consisted of flies, leafhoppers and other soft-bodied insects. *Gerris remigis* Say and *Gerris marginatus* Say were kept under the same conditions with about the same degree of success.

Trepobates pictus H. S.

This rather cosmopolitan little Gerrid is peculiarly local in distribution, although exceedingly abundant where found. In Minnesota it has been found chiefly in the quiet eddies of moving water, especially spring fed pools. This prettily marked insect has a variable color pattern of black, varied by pale and yellow, making the collection of a large series of more than ordinary interest. While this variation adds to their interest, it also adds to the difficulty of describing them.

These alert little bugs are gregarious and were often seen in schools of several hundred. Hungerford (1919) is the only American worker who has given us biological data regarding this species. Drake (1915) contributed to our knowledge of the water striders by giving the length of the developmental period in *Gerris conformis* Uhler and *Tenagogonus hesione* Kirk. Bueno (1917) published life-history and habit notes on *Gerris remigis* Say and *Gerris marginatus* Say.

Trepobates pictus H. S. is not easily kept in captivity and that perhaps explains why it has not been reared heretofore. Hungerford describes and figures the egg and the first instar nymph. He secured nymphs in June, early enough in the season to have reared the species. He probably encountered difficulty in his rearing attempts.

Field observations would indicate that *T. pictus* spends the winter as an adult. Its hibernation is probably much like that of *Gerris marginatus* Say.

The mating, often observed in both the laboratory and field, presented no variation from that found in the other *Gerrids*. In aquaria they have been observed to remain in coitu for long periods at a time. The female often jumped about while mating, the male upon her back appearing not to cause her much concern. She was also observed to feed while mating.

No data were obtained relative to the preoviposition period. The two females reared from the egg were mated upon emergence as adults, but no eggs were secured. A number of fifth instar nymphs were brought in from a nearby pond and carried through to the adult state. These likewise did not deposit eggs. Females collected July 18 deposited several batches of eggs that night. These eggs hatched in twelve days. On August 26 a pair of mating apterous *Trepobates* was taken from Spring Lake. The following night the female laid a mass of nine eggs on the underside of a small willow twig that was placed in the aquarium jar. These eggs did not hatch. Another mating pair was taken at the same time and placed as the above mentioned pair. This female also deposited eggs on the second night and peculiarly enough, a mass containing nine eggs. It is interesting to note in this connection that the egg-laying took place the second night the bugs were placed in captivity. *Microvelia* reared in captivity and depositing eggs every day usually will fail to deposit eggs the first day they are placed in a new breeding jar. This delayed oviposition had been taking place for some time before the writer correlated it with a change of environment. After that suspicion suggested itself, a number of transfers were made to determine how constantly it happened. Nine times out of ten no eggs were deposited the first day spent in a new environment. On the occasions when egg-laying did take place, usually only one egg was deposited.

The second female, referred to above, placed six egg masses during a period of nine days. In numbers the masses contained 9, 9, 4, 2, 3, and 3 eggs, a total of thirty eggs. The eggs from this female were infertile.

DESCRIPTION OF THE STAGES.

The egg.—The eggs were 1.057 mm. long. Their greatest width was .264. The eggs were slender and tapering at the end. The cephalic end of the egg is more pointed than the caudal end.

First instar.—Measured dorsally along the median line gave a length of 1.123 mm. for a first instar two days old. Head across eyes .297 mm.; length of posterior tibia .330 mm. Coloration very suggestive of what we found in the *Gerris buenoi* Kirk. first instar nymph. Body brownish-yellow with head, antennæ, legs and two elongated spots on the meso-thorax, brown. Median pale line had shape of an inverted V on the pronotum, was a round spot on the line between the pronotum and the base of the head, and formed the outline of a glass tumbler on the head.

The posterior margin of pronotum was pale. The pronotum and metanotum about subequal in length with their combined length being less than that of the very long mesonotum. Metanotum had two short and narrow transverse darker lines. On each abdominal segment there were four short dark transverse lines, a pair to either side of the pale median line. They appeared as the "equals" sign used on typewriter keyboards. The median pale line gradually became narrow from the posterior margin of the pronotum to the apex of the abdomen, thus forming a broad exclamation mark, the genital segment forming the dot to complete the exclamation mark.

Second instar.—Length 1.454 mm.; width, head across eyes, .396; length of posterior tibia .363 mm. This nymph had a leg caught in the nymphal skin and for that reason died almost immediately upon molting. The entire bug remained pale as they always are immediately upon molting. For this reason the color pattern cannot be compared with that of the first instar.

Third instar.—1.983 mm. long; width of head across eyes, .594 mm.; length of posterior tibia .396 mm. The nymph at this early stage had markings surprisingly near in appearance to those found in adult specimens. The dark portion on the top of the head looked like a capital W, with the center portion rather broad and extending forward toward the base of the rostrum. The dark markings on the pronotum can be likened to inverted, irregular capital U's. There were two such markings. Each half of the mesonotum had a yellowish spot on its center. This was surrounded by a black or at least dark circle and this in turn encircled by a yellow circle.

Fourth instar.—This nymph was a few hours old when measured. Length 1.983 mm.; width, head across eyes .694 mm.; length of posterior tibia .429 mm. Color markings much as in the third instar excepting that the black had become more extensive at the expense of yellow.

Fifth instar.—A specimen seven days old was measured to secure the data for this instar. Length along median line was 3.106 mm.; width, head across eyes .859 mm.; length of posterior tibia .892 mm. The black and yellow markings appeared more contrasty in this instar. The yellowish spots on the abdomen had arranged themselves in four rather definite rows.

This species is hard to handle in aquaria. The first difficulty was encountered in attempting to transfer the nymphs from the container in which they hatched to an individual life history jar, where accurate account might be kept on the molting. My first efforts were rewarded by transferring the nymphs to the floor instead of the new breeding jar. Finally in desperation a rather drastic procedure was resorted to. The nymphs were sucked up in a large pipette and then forced into jelly glasses in which they were reared.

The jelly glasses were three inches deep, with a diameter of two inches at the base and of two and one-half inches at the top. The glasses were filled half full of water. Imagine the writer's surprise when he learned that the tiny nymphs could negotiate the inch and a half, almost vertical, distance that stood between them and freedom.

Summary.—By reference to Table I we learn that a total of only six bugs was reared from egg to maturity, out of a start of twenty-three rearings. The nymphs hatched from eggs deposited by winged adults. There were four males and two females reared, all being apterous. The average duration of the first instar for 15 specimens was 7 days (minimum 5, maximum 9); the average nymphal life of 14 second instar bugs was 5.9 days (minimum 5, maximum 8 days); the average for eleven third stage bugs was 7.9 (minimum 5, maximum 12 days); the average for nine fourths was 9.3 days (minimum 8, maximum 10 days); the six fifth-stage nymphs lived 10.6 days as an average, with 8 days as a minimum and 12 days as a maximum. The average duration of the nymphal existence for the six reared to the adult state was 39 days, with a minimum of 36 and a maximum of 42 days. Adding a twelve day incubation period we have a total of 48 to 51 days as the developmental period from egg to adult.

TABLE I.

Record of Rearings of *Trepobates pictus*.

Rearing Number	First instar	Second instar	Third instar	Fourth instar	Fifth instar	Total Days	Sex	Date
								1923
220	6	7	7	10	12	40	♂	Sept. 11
221	7	6	8	10	11	42	♂	Sept. 11
222	d	.....	.....	.....	.....	.....	.....	.....
223	8	d	.....	.....	.....	.....	.....	.....
224	9	5	7	9	d	.....	.....	.....
225	6	6	d	.....	.....	.....	.....	.....
229	d	.....	.....	.....	.....	.....	.....	.....
236	6	d	.....	.....	.....	.....	.....	.....
237	8	6	10	10	.....	.....	.....	.....
238	d	.....	.....	.....	.....	.....	.....	.....
239	6	d	.....	.....	.....	.....	.....	.....
240	7	6	d	.....	.....	.....	.....	.....
241	9	d	.....	.....	.....	.....	.....	.....
242	d	.....	.....	.....	.....	.....	.....	.....
243	5	6	5	10	11	36	♀	Sept. 6
255	7	5	7	10	11	40	♀	Sept. 11
256	7	8	d	.....	.....	.....	.....	.....
257	.....	5	8	k	.....	.....	.....	.....
258	7	6	8	8	11	40	♂	Sept. 13
259	.....	6	12	8	d	.....	.....	.....
260	.....	5	8	d (19 days)	.....	.....	.....	.....
261	7	5	7	9	8	36	♂	Sept. 9
262	d	.....	.....	.....	.....	.....	.....	.....
Average	7 for 15	5.9 (14)	7.9 (11)	9.3 (9)	10.6 (6)	39(6)	.....	.....
Minimum	5	5	5	8	8	36	.....	.....
Maxi'm	9	8	12	10	12	42	.....	.....

Males, 4; Females, 2. d—died. k—killed.

Gerris buenoi Kirkaldy.

This species is not recorded from Minnesota, according to Van Duzee's Catalogue. Such, however, does not indicate a paucity of this species, but rather indicates a scarcity of collecting records. Two score or more of additions have been made to the list of aquatic Hemiptera of Minnesota during the past three years, thus it is evident that Van Duzee's Catalogue is not a true index of the Minnesota aquatics. Up to the time of description it had been confused with the margined water strider (*Gerris marginatus* Say) which was described in 1832. Although *G. buenoi* Kirkaldy was not described until 1911, it is the most common strider found in Minnesota. It frequents habitats similar to those in which we find *Gerris marginatus*, namely, ponds, pools, and the slower, more sluggish streams.

This Gerrid hibernates as an adult. It has not been taken in a state of hibernation in Minnesota, but presumably it hibernates under drift, leaves and trash on the banks of aquatic environments. It has been taken as late as November and as early as the first part of April. So far as known to the writer there has been nothing recorded in the literature concerning its biology.

The mating of *Gerris buenoi* Kirk. was not observed in the laboratory. Afield its mating habits seem not unlike those of *Gerris marginatus* Say. Hungerford (1919) has a note on the mating of the last named species and also figures a pair in coitu.

Eggs have been found deposited on small floating sticks and grass stems out in nature. In the laboratory the eggs were deposited on sticks, stems, bark and other floating material that was supplied. Only one egg is laid in a place, being set more or less obliquely on its support and surrounded by a gelatinous mass. Eggs have been collected as early as the middle of June. Very little opportunity has been had to make field observations in the spring of the year, so data of this nature are meager. One adult female brought into the laboratory July 7 deposited 34 eggs by July 12. Another brought in on the first of July died the sixth day, having deposited but one egg during the interval. Numerous specimens were collected in the field throughout the months of July and August. Some of these deposited eggs and some did not. Those that did not deposit eggs usually died in a day or so, showing that they were probably spent individuals.

Eggs laid in the laboratory July 22 hatched in eleven and twelve days. Twenty eggs deposited August 22 all hatched on the tenth day. These were deposited by several females collected about a week earlier.

The behavior of the newly hatched was very similar to the young nymphs of *Limnoporus rufoscutellatus* Latr.

There are five nymphal stages. Previous to molting the nymphs become swollen, somewhat darker in color and less active.

Female number 199, which emerged to the adult state August 12, was kept alive for a month and a half. No eggs were deposited, and although several males were added to the aquarium, mating was not observed. Unfortunately this did not give any data on maturity. Since mating specimens brought in from the field did not resume mating it was not surprising that reared specimens did not mate. It would be desirable to rear some specimens early in the season in order to ascertain whether or not eggs are deposited the same season the specimen becomes an adult. The aquaria used by the writer were so small that it was impossible to provide ideal conditions. With aquaria large enough to accommodate growing plants more satisfactory studies could be made.

The food habits and behavior of *G. buenoi* were very similar to those of *G. marginatus* Say.

DESCRIPTION OF THE STAGES.

The egg.—Length 1.187 mm.; greatest width .297 mm.; rather abruptly rounded at each end.

First instar.—A specimen two or three days old measured as follows: Length 1.652 mm.; width head across eyes 1.462 mm.; greatest body width .727.

Second instar.—The only measurement secured was that of the width of the head across the eyes, that being .561 mm. in a nymph two days old.

Third instar.—Measured dorsally the same day it attained the third stage gave the following: Length along median line 2.313 mm.; width, head across the eyes, .826 mm.; greatest body width .925 mm. The suture separating the head from the thorax glistening in appearance, as were also the large irregular spots on the thorax. There were glistening spots on the abdomen, too.

Fourth instar.—Measured as for the preceding instar. Length along median line 3.800 mm.; greatest body width 1.090 mm.; head across eyes .991 mm.; greatest width of mesothoracic wing pads .991 mm. Pronotum brown except for a median paler line which flares out before the posterior margin is reached. Distribution of the light and dark

colors on the rest of the thorax, formed a beautiful pattern. Wing pads apparent, shiny and glabrous; tips of metathoracic wing pads extending .165 mm. caudad of the mesothoracic wings.

Abdominal segments had shiny light-colored spots on either side of each segment of the connexivum. On either side midway between the median line of abdomen and junction of abdomen with the connexivum, there was a row of spots. The spots were brown glabrous ones, surrounded on all sides but the anterior by irregular borders of a color not unlike that forming the spots on the connexivum.

Fifth instar.—Length along median line 5.453 mm.; head across eyes 1.255 mm.; greatest width of mesothoracic wing pads (which then completely covered the metathoracic wing pads) 1.288 mm. Tips of wing pads extended to a point on a line with the apical portion of the posterior coxæ. Dorsal abdominal spots much as in the fourth stage.

Summary.—Table II shows the history of the rearings of *Gerris buenoi* Kirk. Only two specimens were carried through to maturity, both of them being females. Ten life histories were started and the conditions for each were made as much alike as possible. The average length of the first instar, for seven specimens, was 4.7 days, (minimum 4, maximum 6 days); the average length of five second-stage nymphs was four days (minimum 2, maximum 6 days); the average length of the four third-instar nymphs was 5.2 days (minimum 3, maximum 10 days); one fifth instar Gerrid reached maturity in 21 days, the other required 35, thus making an average of 28 days. With the addition of the ten-day incubation period we have a total developmental period ranging from thirty-one to forty-five days.

TABLE II.

Record of Rearings of *Gerris buenoi* Kirkaldy.

Rearing Number	First instar	Second instar	Third instar	Fourth instar	Fifth instar	Total Days	Sex	Date
								1923
199	4	3	4	4	6	21	♀	Aug. 12
201	4	4	3	d2	.....	.....	.....	.....
386	d	.....	.....	.....	.....	.....	.....	.....
387	6	d	.....	.....	.....	.....	.....	.....
403	4	5	7	10	9	35	♀	Oct. 7
404	4	6	7	8	d	.....	.....	.....
405	5	2	d	.....	.....	.....	.....	.....
406	d	.....	.....	.....	.....	.....	.....	.....
407	d	.....	.....	.....	.....	.....	.....	.....
408	6	d	.....	.....	.....	.....	.....	.....
Average	4.7	4	5.2	7.3	7.4	28	.....	.....
Minimum	4	2	3	4	6	.....	.....	.....
Maxi'm	6	6	7	10	9	.....	.....	.....

Males, 0; females, 2. d—died.

Limnoporus rufoscutellatus Latreille.

Although this beautiful brown species has been known for over a century and said to be the most cosmopolitan of all waterbugs, practically nothing was known about its life history until Drake (1922) gave notes on the incubation period and duration of nymphal life. He found the eggs to hatch in "about ten days or two weeks." Some of the adults appeared thirty-four days after the time of hatching, but most of the specimens required several days longer to reach the adult stage. No data were given on the number of instars nor the duration of instars.

This insect hibernates as an adult and appears early in the spring. It frequents still waters that are not too stagnant or small. It is found especially numerous in spring fed pools.

The mating takes place early in the spring and is not unlike the mating of other species of *Gerrids*. In captivity they did not mate often, but this may be due to the fact that they were kept in rather small containers.

The preoviposition period was not determined as the adults reared failed to lay eggs. Drake found the eggs to be deposited just beneath the surface film of the water upon floating objects. He did not mention the fact that they are enclosed in a gelatinous mass. In aquaria eggs were deposited on rocks and floating pieces of bark, sometimes singly, sometimes in rows. When deposited on sticks or pieces of bark, the eggs were usually arranged in a row. They were set obliquely, but were not in contact. If rearranged in a straight row, their ends would almost touch.

Observations on a gravid female taken June 30 gives some idea of the fecundity of this species. This adult lived thirty days in captivity and in that period deposited 110 eggs, or an average of three and two-thirds eggs per day. On the night of July 7, thirteen eggs were laid. Most of these were placed on the upper side of the small piece of bark, but a few were on the under side. It is probable that the bit of bark was overturned when the female attempted to place an egg near to the edge. Eggs were deposited both during the day and during the night, but the greater number were deposited at night.

Eggs laid in July hatched in eight, nine and ten days. The actual hatching was not observed. The container in which the

eggs were laid was four inches deep, making close observation impossible. Only a few of the eggs were fertile and it so happened that those removed to shallow containers were all infertile.

There were five nymphal stages and in Table No. III is given the duration of each.

Three and one-half months was the longest period that any specimen of this species was kept in captivity. The adults appearing in the spring are still alive when the earliest nymphs reach maturity during the summer. Unless they are always the individuals which reached maturity very late the preceding fall, which seems improbable, they would be a full year and more of age.

Limnoporus rufoscutellatus, like the other members of the family *Gerridæ*, is predacious, feeding upon insects to be found on the surface of the water. Various insects were fed to those reared in aquaia. I once disturbed a third-stage bug as it was feeding upon a leafhopper nymph. Much to my surprise I witnessed the *Gerrid* jump a considerable distance, carrying the leafhopper with it, although the latter was considerably larger than the *Limnoporus*.

The adults prefer to cling to vegetation or other support most of the time. Occasionally they stride from one support to another or out into the open water for food. They do not frequent the open water. Often a pond may be approached and no *Gerrids* in sight. Then, upon getting closer to the water's edge dozens of *Limnoporus* will dart out from the bank. They either reach a support at some distance from the shore line or circle and return to the shore at a point above or below the collector.

The nymphs of this *Gerrid* seem to be more independent of supports as they were reared in jelly glasses with no supporting surface whatever afforded.

DESCRIPTION OF STAGES.

Egg.—Length 1.289 to 1.322 mm.; greatest width, .439–.495 mm., elongate-oval and taper at both ends. One end is more pointed than the other.

First instar.—Nymphs about two days old measured dorsally as follows: Length along median line 1.520 mm.; width of head across eyes .495 mm.; width across posterior margin of thorax .495 mm. Color is brownish-yellow with the head, prothorax and legs brown. There is also a brown spot on each side of the meso- and metathorax.

There is a pale median line on the body. This forks at the base of the head, the forks extending outward in front of the eyes. These measurements as also those of the egg were made from preserved material. The following measurements were made from the living specimens. They are only approximately correct as the nymphs will not stay in one place long enough to allow of making accurate measurements. Furthermore, the nymphs always have the anterior portion of the body elevated (except when feeding) and this makes measuring very difficult. However, the error is probably proportionate for the several stages.

Second instar.—Nymph a few hours old measured dorsally as follows: Length along median line 2.313 mm.; width of posterior margin of thorax .826 mm.

Third instar.—Nymph a few hours old measured dorsally as follows: Length along median line 2.974 mm.; width head across eyes .924 mm.; width of posterior margin of thorax .991 mm.

Fourth instar.—A description of the fourth stage was not recorded on the life history cards as a specimen was preserved. The bottle containing this stage was later broken and there is no material at hand from which measurements may be made. In this instar the wing pads appear. They are rather small and their dark brown color more than their size makes them apparent.

Fifth instar.—A nymph a few hours old measured dorsally as follows: Wing pads 3.23 mm. in length; reaching within 1.322 mm. of the tip of the abdomen.

These bugs were reared in jelly glasses half filled with water. Sand was not used in the containers. Care had to be taken not to disturb the nymphs. When disturbed they would make frantic efforts to escape and would often become waterlogged. When the body becomes waterlogged, or in other words, the body pile thoroughly wetted, the bugs will drown unless removed to an aquarium containing only wet sand. After the body is again clean and dry and the bug recovered from the weakening effects of its struggles, it may be returned to the aquarium containing water. I have never observed a waterlogged bug which managed to pull itself upon a support. In fact if they be placed on supports in the ordinary aquarium jar they will immediately plunge into the water again.

Summary.—It may be observed from Table No. III that four specimens were reared to maturity. Of this number one was a male and three were females. There were five nymphal stages. The average length of the first instar was 3 days (minimum 2, maximum 4 days); average length of second instar was 3 days (minimum 2, maximum 4 days); average length of third instar was 2.7 days (minimum 2, maximum 3 days); the length of the

fourth instar was the same in all four nymphs, namely, four days. The average length of the fifth instar was 6.2 days (minimum 6 days, maximum 7 days). The average span of nymphal life was 19 days, with a minimum of 18 and a maximum of 21 days. Adding the nine days (average length of incubation period) we have a total developmental period ranging from 27 to 30 days, the average being 28.3 days.

If the preoviposition period is proportionately as short as the developmental period, two or three generations a year might be expected. Drake points out that field observations indicate two generations a year in the Adirondacks. Field observations in Minnesota would lead one to believe that there is but one generation per year.

TABLE III.

Table of Rearings of *L. rufoscutellatus* Latreille.

Rearing Number	First instar	Second instar	Third instar	Fourth instar	Fifth instar	Total Days	Sex	Date
								1923
118	4	3	3	4	7	21	♀	Aug. 4
181	2	4	3	4	6	19	♀	July 31
185	3	3	2	4	6	18	♂	Aug. 2
190	3	2	3	4	6	18	♀	Aug. 4
191	.....	.....	.....	.....	.....	.....	.....	.....
Average	3	3	2.7	4	6.2	19	.....	.....
Minimum	2	2	2	4	6	18	.....	.....
Maxi'm	4	4	3	4	7	21	.....	.....

Males, 1; Females, 3.

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UNDESCRIBED SPECIES OF JAPANESE CRANE-FLIES.*

PART V.*

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Massachusetts Agricultural College.

The preceding parts under this general title were published in these ANNALS in 1919, 1921, 1923, and 1924. The species described at this time are chiefly from the mountains of Honshiu and Kiushiu, where they were collected by my friends, Messrs. Esaki, H. Hori, Machida, Takeuchi and Yokoyama. A few additional forms were taken in Hokkaido by Messrs. M. Hori and Kuwayama. Still other species from Saghalien, the Loochoo Islands and Taiwan were taken by Messrs Kuwayama, Sakaguchi and Takeuchi, respectively. My sincere thanks are extended to all of the above collectors for their kind co-operation in making known the very extensive Tipuloidean fauna of the Japanese Empire. The types of the new species are preserved in the collection of the writer.

The question has been raised by Professor Cockerell as to whether Taiwan (Formosa) should justly and correctly be included in a paper having a general title such as the present one. A great number of works and papers on Japanese insects have included Taiwan in their scope and the writer can see no vital objection to such a course, either from a faunistic or political viewpoint. I am greatly indebted to my friend, Professor Teiso Esaki, for an expression of his opinion as to what should be considered as being "Japan Proper," and what possessions fall outside this strict application. Professor Esaki has an intimate first-hand knowledge of virtually the entire Empire, having travelled and collected from Saghalien to Taiwan, and his opinions may be taken as authoritative: "I believe that in its strict sense, Japan should be considered as consisting of *Honshiu* (Hondo, the main island of Japan), with Sado, Oki, Awaji and Izu Islands (Oshima, Hachijojima, Miyakejima, etc.); *Shikoku; Kiushiu* (with Iki, Tsushima and Osumi Islands), and *Hokkaido* (Yezo) with the Kurile Islands.

* Contribution from the Department of Entomology, Massachusetts Agricultural College.

The Loochoo (Riukiu) Islands, including Okinawa, and the Bonin Islands (Ogasawarajima) are not included in Japan Proper. Likewise, the new domains of the Japanese Empire, i. e., Formosa (Taiwan), Southern Saghalien (Karafuto) and Corea (Chosen) are not included in Japan Proper."—Esaki.

Dicranomyia Stephens.

Dicranomyia (Euglochina) okinawensis sp. n.

Male. Length, 8 mm.; wing, 8.8 mm.

Female. Length, about 7 mm.; wing, 7.5 mm.

Generally similar to *D. (E.) fuscibasis* Alexander (India), differing as follows: Size larger. Infuscated proximal ends of basitarsi narrower, broadest on posterior legs where about the basal fifth is darkened. Wings tinged with brown, the oval stigma a little darker brown. Venation: *Sc* short, Sc_2 near the tip of Sc_1, the distance between the end of the latter and the origin of *Rs* fully three times *Rs; Rs* angulated and spurred near midlength; cell *1st* M_2 elongate-rectangular, longer than any of the veins issuing from it; basal deflection of Cu_1 just before midlength of cell *1st* M_2.

Habitat: Japan (Loocho Islands). Holotype, ♂, Kunjan-gun, Okinaw, altitude 500–1,000 feet, May, 1923, (S. Sakaguchi).

Dicranomyia kirishimana sp. n.

General coloration dark brown, the thorax with silvery patches; legs yellow, the femoral tips conspicuously dark brown, the tibial bases and tips narrowly infuscated; wings whitish subhyaline, with a heavy brown crossbanded pattern.

Male. Length, 5 mm.; wing, 6.5 mm.

Rostrum black, the palpi dark brown. Antennal scape brownish black; flagellar segments oval, obscure yellow, the tips weakly infuscated to produce an indistinct bicolorous effect, the terminal segments more uniformly infuscated. Head silvery gray, the vertex with a black longitudinal mark on either side of a subequal median gray stripe, these marks continued to the occiput; genæ duller gray.

Pronotum and mesonotum brownish black with silvery patches, the praescutum with a median stripe of the ground color; scutellum and postnotum silvery pruinose. Pleura silvery gray, with a vague longitudinal brownish black stripe across the mesopleura. Halteres relatively short, pale yellow, the large knobs dark brown. Legs with the coxæ dark brown, vaguely pruinose; trochanters concolorous, the tips paler; femora yellow, the tips conspicuously dark brown; tibiæ yellow, the bases narrowly but conspicuously dark brown, the tips narrowly and less distinctly infuscated; tarsi yellow, the terminal segments passing into brown. Wings whitish subhyaline, the extreme base yellow; a heavy and conspicuous brown and gray pattern that assumes the form of five

irregular crossbands; cell *C* with three of these marks, restricting the interspaces to narrow quadrate areas, the marks continued into cell *R*, where they are gray, bordered with brown, ending abruptly just before reaching vein *M;* the fourth or stigmal band includes the stigma and is confluent with a circular, pale-centered ring at the fork of *Rs*, connected outwardly with the fifth or subterminal band; narrow brown seams along the cord and outer end of cell *1st* M_2; wing-apex and very extensive but vague cloudings at the tips of all the longitudinal veins, pale gray; veins dark brown, the wing-base, *C*, *Sc* and *R* yellowish. Venation: Sc_1 ending just beyond the origin of *Rs*, Sc_2 not evident in the type-specimen; *r* at tip of R_1; cell *1st* M_2 elongate-rectangular, a little shorter than M_{1+2} beyond it; basal deflection of Cu_1 just before the fork of *M*.

Abdomen dark brown, the subterminal segments passing into black; fleshy dististyle of male hypopygium paler brown.

Habitat: Japan (Kiushiu). Holotype, ♂, Mt. Kirishima, on boundary between Osumi and Hiuga, altitude 3,250 feet, October 30, 1923, (T. Esaki).

Dicranomyia pammelas sp. n.

Head and thorax shiny coal-black; fore femora largely black with a subterminal obscure yellow ring; wings whitish subhyaline, the base and costal region conspicuously light yellow, the disk with a heavy brown pattern.

Male. Length, 7 mm.; wing, 7.2 mm.

Rostrum and palpi black. Antennæ with the scapal segments black, the flagellar segments brown, the latter oval, becoming more elongate and darker colored outwardly. Head black, very sparsely pruinose.

Pronotum and mesonotum shiny coal-black, the cephalic margin of the postnotal pleurotergite with a narrow line of silvery microscopic pubescence. Halteres yellow, the apices of the knobs conspicuously dark brown. Legs with the coxæ shiny black, narrowly paler apically; trochanters obscure yellow; fore femora black, the basal fourth obscure yellow, before the apex with a narrow obscure yellow ring that is about one-half as wide as the dark tip; remaining femora obscure yellow, the tips conspicuously blackened; tibiæ and tarsi brownish yellow, the tips narrowly and indistinctly infuscated; tarsi brown, passing into black. Wings whitish subhyaline, the base and costal region conspicuously light yellow; a heavy brown pattern, distributed as follows: A blotch at end of *Sc*, confluent with a larger area at origin of *Rs;* stigma oval and slightly darker brown; a circular spot at fork of *Rs*, barely touching the stigma; cord and outer end of cell *1st* M_2 conspicuously seamed; wing-apex extensively darkened, this including the outer half of cell *2nd* R_1, outer two-thirds of cells R_3, R_5, and almost all of cells *2nd* M_2 and M_3; a conspicuous cloud along vein *Cu* in cell *M* and conspicuous marginal clouds at ends of all the longitudinal veins; anal angle more or less darkened; veins dark brown, yellow in the flavous areas. Venation: *Sc* short, Sc_1 ending shortly beyond the origin of *Rs*, Sc_2 at its tip; *r* at tip of R_1, the latter beyond it very short; *Rs* feebly angulated at base;

R_{4+5} longer than the basal section of R_{2+3}; cell *1st* M_2 relatively small, subrectangular; basal deflection of Cu_1 about one-half its length before the fork of *M*.

Abdomen black, the caudal margins of the segments narrowly pale; hypopygium black.

Habitat: Japan (Honshiu, Kiushiu). Holotype, ♂, Mt. Minomo, Settsu-no-kuni, June 22, 1922, (T. Esaki). Paratypes, ♂ ♂, Kashii, near Fukuoka, Kuishiu, June 11, 1924, (H. Hori).

Dicranomyia pammelas bears a marked resemblance to *D. takeuchii* Alexander (Japan), differing conspicuously in the wing-pattern, there being no conspicuous brown clouds in the radial field basad of the origin of *Rs*.

Libnotes Westwood.

Libnotes puella sp. n.

Belongs to the *poecilоptera* group; allied to *L. strigivena* (Walker); size very small (wing, ♀, less than 10 mm.); antennal flagellum brownish black throughout; thoracic pleura narrowly lined with dark brown; femora with narrow and relatively indistinct brown subterminal rings; *r* at the tip of R_1.

Female. Length about 9 mm.; wing 9.5 mm.

Rostrum and palpi pale brown. Antennal scape obscure brownish yellow, the flagellar segments brownish black, broadly oval with short pedicels; terminal segments passing into elongate-oval. Head obscure rufous medially, the vertex more infuscated, the orbital region gray; vertex between the eyes reduced to a narrow strip.

Pronotum brown, pale laterally. Mesonotal praescutum obscure yellow with three confluent brown stripes, the broad median stripe irregular, becoming abruptly obliterated, brownish gray, before the suture and more or less constricted near midlength; the narrow lateral stripes touch the median stripe at their anterior mesal ends; lateral margin of the praescutum infuscated; remainder of the mesonotum light gray pruinose, the lateral half of each scutal lobe and the broad lateral margins of the postnotal mediotergite conspicuously infuscated. Pleura light gray pruinose, less so in front, with two narrow dark brown longitudinal stripes, the dorsal one beginning on the cervical sclerites, crossing the propleura and anepisternum onto the pteropleurite; the ventral stripe begins on the fore coxa, crosses the sternopleurite onto the extreme dorsal edge of the meso-coxa and meron. Halteres yellow, the knobs infuscated. Legs with the coxæ and trochanters pale brownish testaceous, the coxæ marked with brown as described above; femora yellow with a narrow brown subterminal ring about its own length before the yellow tips; tibiæ and basitarsi obscure yellow, the tips narrowly infuscated; terminal tarsal segments brownish black. Wings pale yellow, rather sparsely variegated with small brown spots and gray dots and clouds; the brown spots occur on the veins at intervals, as in

the *poeciloptera* group; the gray clouds and dots occupy all the cells, becoming somewhat larger along the posterior margin of the wings; veins yellow, dark brown in the infuscated areas. Venation: *r* at tip of R_1 and a little longer than it; *Rs* about one-half longer than the deflection of R_{1+5}; *m* about twice the outer deflection of M_3, gently arcuated; basal deflection of Cu_1 more than its length beyond the fork of M.

Abdomen obscure brownish yellow, the extreme lateral margins of the segments dark brown, forming a narrow pleural stripe. Ovipositor with the bases of the valves black.

Habitat: Japan (Kiushiu and Loochoo Islands). Holotype, ♀, Mt. Kirishima, on boundary between Osumi and Hiuga, Kiushiu, altitude 3,250 feet, October 30, 1923, (T. Esaki). Paratypes, 2 ♀ ♀, Iriomote, Loochoo Islands, altitude 300–500 feet, Late July, 1923, (S. Sakaguchi).

Molophilus Curtis.

Molophilus (Molophilus) albohalterata sp. n.

General coloration black; antennæ short in both sexes; halteres conspicuously yellowish white; wings strongly tinged with brown, the extrême bases paler.

Male. Length, 3–3.5 mm.; wing, 4–4.5 mm.

Female. Length, 3.6–4.4 mm.; wing, 4.4–4.8 mm.

Rostrum and palpi black. Antennæ short, the basal segments black, the terminal segments passing into dark brown. Head black.

Thorax entirely black. Halteres very conspicuously pale yellowish white. Legs brownish black throughout. Wings strongly tinged with brown, the extreme base pale; distal half of the wing a little paler than the basal half; veins and macrotrichiæ darker brown. Venation: R_1 deflected cephalad beyond *r;* basal deflection of Cu_1 about two-fifths the fusion of $M_{3+4}Cu_1$; vein *2nd A* long and sinuous.

Abdomen black, including the hypopygium. Male hypopygium with the apical style a small, sickle-shaped hook, the points directed dorsad, each with a small erect spine at its base; basal dististyle slender, straight, the slender apex blackened and provided with microscopic setæ, the appendage barely exceeding the apices of the basistyle and not reaching the tip of the long, straight, yellow aedeagus. Apex of each basistyle on the apparent dorsal face produced caudad into a long, stout, digitiform lobe, the apex of each contiguous on the mid-dorsal line. Ovipositor with the valves horn-colored; tergal valves stout, only gently upcurved.

Habitat: Japan (Honshiu). Holotype, ♂, Mt. Takao, Musashi-no-kuni, altitude 1,000–2,000 feet, May 7, 1922, (T. Esaki). Allotopotype, ♀. Paratopotypes, 9 ♂ ♀.

Rhabdomastix Skuse.

Rhabdomastix (Sacandaga) atrata sp. n.

Coloration brownish black throughout, including the halteres and legs; wings strongly tinged with blackish; tips of R_1 and R_2 remote from one another.

Male. Length about 3.3 mm.; wing, 3.4 mm.

Rostrum and palpi brownish black. Antennæ short, black throughout, the flagellar segments oval. Head brownish black.

Prothorax and mesothorax entirely brownish black. Halteres brownish black, the extreme base of the stem vaguely brightened. Legs dark brown, the tarsi passing into brownish black. Wings with a strong blackish tinge, the stigmal region indistinctly darker; veins brown. Anal angle of wing moderately prominent. Venation: Sc_1 ending about opposite midlength of Rs, Sc_2 about three times its length from the tip of Sc_1; R_2 short, remote from the tip of R_1 at the margin, the distance between them along costa being about two and one-half times R_2 alone; inner end of cell *1st* M_2 pointed.

Abdomen dark brown, the basal sternites a trifle paler on their anterior portions; hypopygium brownish black.

Habitat: Japan (Honshiu). Holotype, ♂, Emi-mura, Chiba-Ken, July 6, 1923, (T. Yokoyama).

Cladura Osten Sacken.

Cladura decem-notata sp. n.

General coloration pale yellow; mesonotal praescutum with four black spots; extreme anterior lateral angles of scutal lobes blackened; black spots on anepisternum and sternopleurite; tips of femora and tibiæ narrowly darkened; wings pale yellow, *r-m* faintly seamed with brown.

Female. Length, 6.5 mm.; wing, 8–8.2 mm.

Rostrum and palpi brownish testaceous. Antennæ pale throughout, the flagellar segments oval. Head brownish yellow.

Pronotum light yellow throughout. Mesonotum pale yellow, with two oval to linear intermediate black spots, representing the anterior ends of the usual praescutal stripes; lateral stripes represented by slightly larger black spots; scutum similar, the extreme anterior lateral angles with a triangular black spot; remainder of mesonotum yellowish testaceous. In one paratype, the posterior margin of the postnotal mediotergite with two oval black spots. Pleura yellowish testaceous, with an elongate-triangular black spot on the anepisternum and a smaller and more diffuse brownish black one on the posterior lateral portion of the sternopleurite, the latter sometimes weakly indicated. Halteres pale, the knobs weakly infuscated. Legs with the coxæ and trochanters yellowish testaceous; femora yellow, the tips narrowly infuscated; tibiæ yellow, the tips narrowly blackened; basitarsi obscure yellow, soon passing into brown. Wings with a pale yellow tinge, the

base and costal region more saturated yellow; an indistinct brown seam on *r-m;* veins dark brown, *C*, *Sc*, *R*, base of *Cu* and the veins at the wing-base more yellowish; squamal region of the wing blackened. Venation: Sc_1 extending to beyond the base of R_2, Sc_2 a short distance before the fork of R_{2+3}; petiole of cell M_1 from once to twice the length of *m;* basal deflection of Cu_1 at or close to the fork of *M*.

Abdominal tergites obscure yellow, the lateral margins extensively pale brown, the color continued across the caudal margins of the segments as narrow borders; sternites pale yellow, the caudal margins narrowly more orange-yellow. Ovipositor with the long valves reddish horn-color.

Habitat: Japan (Kiushiu). Holotype, ♀, Aburayama, Chikuzen, November 17, 1923, (H. Hori). Paratypes, 2 ♀ ♀, Mt. Kirishima, on boundary between Osumi and Hiuga, altitude 3,250 feet, October 31, 1923, (T. Esaki).

Limnophila Macquart.

Limnophila (Prionolabis) neomunda sp. n.

Male. Length, 5.5–6 mm.; wing, 6.8–7.8 mm.

Female. Length about 5.5 mm.; wing 6.7 mm.

Closely related to *L. submunda* Alexander, differing as follows: Legs stouter; wings less extensively clouded with brown, there being no distinct blotch at the origin of *Rs*, no seam along vein of *Cu*, the mark along the cord much more restricted in extent and less conspicuous, and the wing apex scarcely darkened. Venation: Sc_1 ends about opposite mid-length of R_{2+3}, Sc_1 much shorter than in *submunda;* R_{2+3} subequal to or even a little longer than the basal deflection of Cu_1; cell M_1 and its petiole subequal. Hypopygium with the inner dististyle very different in structure; this appendage is relatively small, feebly bifid at apex, the lateral arm very short to subobsolete, with a few yellow setæ, the mesal arm a little longer, its apex with three or four tiny denticles. Outer dististyle with about four teeth in addition to the long apical tooth. Base of aedeagus not reticulate.

Habitat: Japan (Hokkaido). Holotype, ♂, Sapporo, Ishikari-no-kuni, June 1, 1921 (M. Hori). Allotopotype, ♀. Paratopotypes, 2 broken ♂ ♂.

Limnophila (Ephelia) dietziana sp. n.

General coloration light grey, the praescutum variegated with small brown spots and dots; legs light yellow, the femoral tips conspicuously and broadly blackened; wings whitish subhyaline, spotted and dotted with dark brown, all the cells with numerous dots between the larger markings.

Male. Length about 3.6–3.8 mm.; wing, 4.5–5.3 mm.

Rostrum and palpi brownish black. Antennæ with the scape dark brown; flagellum yellow, the base of each segment narrowly infuscated. Head light grey, narrowly dark brown medially.

Pronotum light grey, infuscated medially. Mesonotal praescutum light grey, the usual striped pattern very much broken up into fuscous spots and dots; the median stripe is represented by two parallel or divergent lines before midlength of the sclerite and a single, median, rectangular blotch just before the suture; lateral stripes small, triangular, remote from the suture; between the median and lateral stripes are two small, elongate dashes that are sometimes broken; lateral margins of the praescutum extensively and conspicuously dark brown, including a linear dash anterior to the pseudosutural foveæ; transverse suture with a U-shaped median brown portion, the ends of the U, in cases, with detached dots; scutum grey; each lobe with a small brown triangle; a small caudo-median spot extending onto the scutellum; postnotum gray, extensively infuscated behind. Pleura gray, variegated with dark brown spots. Halteres yellow, the knobs darkened. Legs with the coxæ gray, variegated with brown spots; trochanters light brown; femora yellow, the tips broadly and abruptly blackened, each femur at base on inner face with a linear black dash; tibiæ yellow, the tips narrowly but conspicuously blackened; tarsi yellow, the segments narrowly tipped with dark brown, the terminal segments uniformly infuscated. Wings whitish subhyaline, conspicuously spotted and dotted with dark brown, distributed as follows: A series of five costal blotches, the second at origin of *Rs;* third at tip of *Sc*, fourth at tip of R_1, the last connected along the cord to form a V; fifth area at tip of R_2; wing-apex darkened; smaller spots at the supernumerary cross-vein in cell *M;* along the cord and outer end of cell *1st* M_2; a series along vein *Cu* and one just before the tip of vein *2nd A;* all of the remaining cells of the wing are densely dotted with brown; veins dark brown, paler in the ground areas. Venation: *Rs* square at origin; basal deflection of Cu_1 more than one-half its length beyond the fork of *M*.

Abdomen dark brown, including the hypopygium.

Habitat: Japan (Honshiu). Holotype, ♂, Mt. Hakone, Sagami-no-kuni, altitude 2,300 feet, July 13, 1923, (T. Esaki). Paratype, Sex? Tamagawa, Musashi-no-kuni, September 7, 1922, (J. Machida).

Additional specimens of this very distinct fly are in the collection of Dr. William G. Dietz, in whose honor the species is named.

Limnophila kirishimensis sp. n.

Allied to *L. ochracea* Meigen; general coloration uniformly pale brown, pleura with an incomplete longitudinal pale brown stripe; wings brownish yellow, the stigma darker brown; basal deflection of Cu_1 far out beneath the outer end of cell *1st* M_2.

Male. Length, 6.5 mm.; wing, 7.8 mm.

Female. Length, 7.5–8 mm.; wing, 8.2–8.8 mm.

Rostrum pale brown, the palpi dark brown. Antennæ black, the second scapal segment brown; base of first flagellar segment obscure

brownish yellow; antennæ of male of moderate length, if bent backward extending about to the base of the abdomen, the flagellar segments elongate-oval to fusiform; antennæ of female short, extending about to wing-root. Head gray.

Mesonotum rather uniformly pale brown with a more or less distinct median paler stripe on the praescutum. Pleura obscure buffy with a narrow brown longitudinal stripe extending from the cervical sclerites across the dorsal pleurites to beneath the wing-root. Halteres long and slender, pale brown, the base of the stem narrowly yellow. Legs with the coxæ and trochanters yellow; femora light brown, the tips scarcely darkened; tibiæ and tarsi somewhat darker brown. Wings with a brownish yellow tinge, the elongate oval stigma darker brown; veins brown, more yellowish in the costal region. Venation: Sc_1 ending about opposite one-third the length of R_{2+3}, Sc_2 at its extreme tip; *Rs* angulated and weakly spurred at origin; R_{2+3} longer than the basal section of R_2 and fully twice the basal deflection of Cu_1, gently arcuated; *r* at tip of R_1; distal section of R_2 angularly sinuate; inner ends of cells R_3, R_5 and *1st* M_2 in approximate alignment; cell *1st* M_2 pentagonally rectangular; cell M_1 very deep, its petiole about one-half longer than *m;* basal deflection of Cu_1 far out at the distal end of cell *1st* M_2, the fusion of *M* and *Cu* being subequal to or less than *m;* anterior arculus broken.

Abdominal tergites brown, the caudal margins of the segments vaguely paler; sternites obscure yellow, the bases of the segments a little darkened.

Habitat: Japan (Kiushiu). Holotype, ♂, Mt. Kirishima, on boundary between Osumi and Hiuga, altitude 3,250 feet, October 30, 1923, (T. Esaki). Allotopotype, ♀, October 31, 1923. Paratopotypes, 6 ♂ ♀, October 30–31, 1923.

It seems that this species, as well as *toxoneura* Osten Sacken (Eastern North America), *badia* Doane (Western North America), *ochracea* (Meigen), of Europe, and *illustris* Alexander (Taiwan) should all be referred to *Pseudolimnophila* Alexander or in its near vicinity.

Limnophila inaequalis sp. n.

Related to *L. nemoralis* (Meigen); general coloration dark brown; wings with *r* about five times its length from the tip of R_1; R_{2+3} and basal section of R_{4+5} subequal; abdomen dark brown; gonapophyses of male hypopygium produced apically into long slender points.

Male. Length about 5 mm.; wing 6 mm.

Rostrum, palpi and antennæ uniformly dark brown, the second scapal segment globular. Head dark brown.

Pronotum brown, darker medially. Mesonotum dark reddish brown, very sparsely pruinose, the humeral region of the praescutum a little brighter, the scutal lobes, scutellum and postnotum more heavily pruinose. Pleura plumbeous. Halteres pale. Legs with the coxæ infuscated; trochanters obscure testaceous, the margins dark brown;

remainder of legs brownish yellow, the tarsi becoming darker. Wings with a yellowish tinge, the stigma pale; veins brownish yellow; *r* near proximal end of stigma. Venation: *Rs* angulated at base; R_{2+3} very short, about equal to the basal deflection of R_{4+5}; *r* far from the tip of R_1, approximately five times its length, and about twice its length beyond the fork of R_{2+3}; cell M_1 small, about two-fifths its petiole; cell *1st* M_2 rectangular, the basal deflection of Cu_1 near two-fifths its length.

Abdomen dark brown, the hypopygium paler. Gonapophyses very different from the condition obtaining in *nemoralis* and allies, these being broad at base, a little enlarged beyond midlength, the tips produced into long, slender points, the apophyses decussate or nearly so.

Habitat: Japan (Taiwan). Holotype, ♂, Musha, altitude about 3,500 feet, May 19, 1922, (K. Takeuchi).

Limnophila kuwayamai sp. n.

Allied to *subpoetica* Alexander; general coloration ferruginous; hypopygium black; legs brownish black; wings faintly infuscated, stigma darker brown.

Male. Length, 8 mm.; wing, 8.5 mm.

Rostrum obscure yellowish brown, the mouthparts and palpi dark brown. Antennæ elongate, if bent backward, extending about to one-third the length of the abdomen; scapal segments pale brown, the flagellum black with an erect white pubescence. Head dark brown.

Pronotum dark brown. Mesonotum shiny ferruginous, more yellowish posteriorly. Pleura yellowish testaceous. Halteres broken. Legs with the coxæ and trochanters concolorous with the pleura; remainder of legs brownish black, the femoral bases rather narrowly paler. Wings faintly tinged with brown; stigma darker brown; wing-apex, a small cloud at origin of *Rs*, the cord and outer end of cell *1st* M_2 faintly darkened. Venation: *Rs* angulated and spurred at origin; *r* at tip of R_1; petiole of cell M_1 a little longer than R_{2+3}; basal deflection of Cu_1 just before midlength of cell *1st* M_2.

Abdomen brownish yellow, the tergites somewhat darker laterally; hypopygium and penultimate segment black.

Habitat: Japan (Hokkaido). Holotype, ♂, Sapporo, Ishikari-no-kuni, End of July, 1921 (S. Kuwayama); collector's number 89.

This interesting crane-fly is named in honor of the collector, Professor Satoru Kuwayama.

Tricyphona Zetterstedt.

Tricyphona gaudens sp. n.

General coloration light gray; antennæ 13-segmented, the flagellum obscure fulvous; wings pale brown, the costal region brown with a subcostal darker brown longitudinal stripe, uniting with a conspicuous dark brown seam along the cord; center of the disk in cells R_1, M, and

bases of cells R_5 and *1st* M_2 yellow; Sc_2 beyond the origin of *Rs; r-m* long, sinuous, oblique in position, connecting with *Rs* before the tip; cell *1st* M_2 closed.

Male. Length, 19 mm.; wing, 18 mm.

Rostrum and palpi black. Antennæ short, 13-segmented, the terminal four segments narrowed and crowded; scape black; flagellum obscure fulvous, the basal seven segments stout, short-cylindrical to subglobular; terminal four segments infuscated. Head dark gray, the anterior region of vertex variegated with lighter gray, the orbits narrowly of the same color.

Pronotum dusted with gray, the scutellum brown medially, obscure yellow laterally. Mesonotum light gray, the praescutum with four blue-gray stripes, the intermediate pair separated only by a capillary vitta of the ground-color, the interspaces with golden setæ; scutum light gray, the lobes variegated with blue-gray; scutellum and postnotum light gray. Pleura dark, light gray pruinose. Halteres yellow, the knobs infuscated, especially apically. Legs with the coxæ yellow, very sparsely pruinose; trochanters yellow; femora yellow, the tips conspicuously but rather narrowly dark brown; tibiæ and tarsi dark brown. Wings pale brown, the center of the disk clear yellow; cells *C* and *Sc* brown, bordered caudally by a dark brown longitudinal stripe extending from the wing-root, along cell *R*, following the sector and R_{2+3} to the wing-tip; a broad and conspicuous darker brown seam along the cord; stigma oval, brown; cell R_2 and all but the subbasal region of R_3 darkened; veins brownish yellow, darker in the infuscated areas. Venation: Sc_2 lying about twice its length beyond the origin of *Rs*, the latter very long, straight, the origin strongly arcuated; R_2 uniting with R_1 a little less than its own length from the tip; *r-m* long, sinuous, connecting *Rs* immediately before its tip with M_{1+2}; petiole of cell R_4 about equal to the basal deflection of Cu_1; cell *1st* M_2 closed, *m* a little more than twice the petiole of cell M_1; basal deflection of Cu_1 beyond the fork of *M*, the distance a little less than the basal section of M_{1+2}, the fusion of M_3 and Cu_1, a little longer than the basal deflection of Cu_1 alone.

Abdomen with the basal segment dark brown; segments two and three brown, variegated with obscure yellow, the lateral margins of the subterminal segments broadly light gray; hypopygium brownish black.

Habitat: Japan (Honshiu). Holotype, ♂, Kyoto, May 9, 1923, (K. Takeuchi).

Tricyphona gaudens approaches the type of *Pedicia*, especially in the wing-pattern, although the brown seam along vein *Cu*, characteristic of all known species of *Pedicia*, is lacking in the present form.

Tanyptera Latreille.

Tanyptera angustistylus sp. n.

Size very small (wing, ♂, under 12 mm.); wings with a brownish yellow tinge; tip of vein R_2 atrophied; dististyle of male hypopygium long and narrow.

Male. Length 11.5–12 mm.; wing 9.8–11 mm.

Frontal prolongation of head and palpi black. Antennal scape black, the flagellar segments and branches dark brown. Head black.

Pronotum black, obscure yellow dorso-medially. Thorax shiny black, the dorso-pleural membrane light sulphur-yellow. Halteres yellow, the knobs sulphur-yellow. Legs with the coxæ and trochanters black; femora brownish yellow, brighter basally, the tips conspicuously blackened; tibiæ yellowish brown, the base narrowly, the tip more broadly infuscated; tarsi dark brown; tibial spurs black, densely provided with appressed yellow setæ, especially the posterior pair. Wings with a brownish yellow tinge, the base and costal region brighter yellow; stigma somewhat subcircular, brown; veins dark brown, those in the flavous areas and behind vein *Cu* more yellowish. Venation: Tip of vein R_2 atrophied for from one-half to three-fourths its length back from margin; cell *1st* M_2 small; *m-cu* elongate.

Abdomen black, the sublateral portions of the tergites conspicuously obscure brownish yellow, broader and more distinct on the antepenultimate segment; caudal margins of the segments narrowly obscure brownish yellow, the sternites more broadly so. Male hypopygium large, black; dististyle relatively long and narrow, projecting, narrowed gradually to the blackened tips.

Habitat: Japan (Hokkaido). Holotype, ♂, Mt. Moiwa, Ishikari-no-kuni, June 15, 1923, (S. Kuwayama). Paratopotypes, 3 ♂♂.

Cnemoncosis Enderlein.

Cnemoncosis uniplagiata sp. n.

Female. Length 21 mm.; wing 15 mm.

Generally similar to the genotype, *C. nohiræ* (Matsumura) (*hilgendorfi* Enderlein), differing as follows:

Size much smaller, as shown by the measurements. Dorsum of the frontal prolongation of the head infuscated. Antennæ with the flagellum less conspicuously serrate, the basal flagellar segments rufous. Pronotum broadly yellow medially. Mesonotum with the usual praescutal stripes black, confluent, but leaving parts of the yellow ground-color as humeral triangles and narrow posterior interspaces before the suture; each scutal lobe with a conspicuous yellow spot on posterior margin; postnotal mediotergite with a broad oblique yellow stripe on either side, divergent and narrowed behind. Fore and middle femora with the tips broadly and conspicuously blackened; posterior legs nearly as in *nohiræ*, but the subbasal swelling of the tibia only feebly indicated. Wings subhyaline, the base, costal region and stigma bright yellow; a large, conspicuous brown blotch before the tip, occupying parts of cells *2nd* R_1, R_2, R_3, R_5, M_1, *1st* M_2 and *2nd* M_2; the medial band of the genotype is represented only by a barely visible clouding in cell *R*.

Habitat: Japan (Hokkaido). Holotype, ♀, Maruyama, near Sapporo, Ishikari-no-kuni, July, 1923, (S. Kuwayama). Paratopotype, a teneral ♀ in poor condition.

Tipula Linnaeus.

Tipula macrotrichiata sp. n.

General coloration pale yellowish brown; antennæ of male elongate, the flagellar segments bicolorous; wings yellow, the stigma dark brown; conspicuous brown seams on certain of the veins, most evident on the basal deflection of Cu_1; cell *1st* M_2 small, irregularly quadrangular; conspicuous macrotrichiæ in cells R_3 to *2nd* M_2.

Male. Length about 10 mm.; wing, 12 mm.

Female. Length about 11.5 mm.; wing, 12.2 mm.

Frontal prolongation of head yellow, including the nasus, the ventral surface of the prolongation more infuscated; palpi dark brown. Antennæ elongate, especially in the male, if bent backward extending to opposite midlength of the abdomen; antennæ yellow, the basal swelling of the segments brownish black, the terminal segments becoming more uniformly infuscated; in the female, the antennæ do not extend beyond the wing-root. Head pale brown, indistinctly darker medially; anterior part of front whitish.

Mesonotal praescutum yellowish brown with four very faintly indicated darker brown stripes, the intermediate pair strongly narrowed behind; remainder of mesonotum pale brown, the postnotum in the male more pruinose; pleurotergite with a large, oval, pale area immediately above the base of each halter. Pleura obscure yellow, sparsely pruinose, with two longitudinal blackish stripes, the more dorsal across the ventral margin of the anepisternum, the ventral one across the sternopleurite; ventral margin of meron likewise faintly darkened. Halteres pale brownish yellow, the base of the stem and the knobs clearer yellow. Legs with the coxæ yellow, the fore coxæ weakly infuscated; trochanters yellow; femora obscure yellowish brown, the tips indistinctly darkened; tibiæ and tarsi passing into dark brown. Wings light yellow, the base and costal region still clearer; stigma oval, dark brown; conspicuous brown clouds along *Cu* and its branches; wing-tip infuscated, more evidently in cells R_2 and R_3; longitudinal veins and anterior cord seamed with darker; a brown cloud at tip of vein *2nd A*; veins pale, darker in the infuscated areas. Obliterative areas before the cord. Conspicuous macrotrichiæ in cells R_3, R_5, M_1 and *2nd* M_2, in the female being more extensive in the radial cells. Venation: *Rs* moderately long, gently arcuated; R_2 preserved throughout its length; cell *1st* M_2 small, irregularly quadrangular, *m* being very short; basal section of M_{1+2} and basal section of M_3 subequal, pale; basal deflection of Cu_1 at the fork of *M*, the fusion rather extensive, about equal to *r*; basal deflection of Cu_1 long, sinuous.

Abdomen obscure yellow, the lateral margins of the tergites with a conspicuous dark brown longitudinal stripe, the sutures of the tergites less distinctly infuscated; eighth tergite blackened in male; basal sternites yellow, the intermediate segments more infuscated.

Habitat: Japan (Honshiu). Holotype, ♂, Kyoto, May 12, 1923, (K. Takeuchi). Allotopotype, ♀.

In its general appearance this fly suggests *T. nipponensis* Alexander and allies, but differs conspicuously in the macrotrichiæ of the wings. The obliteration of the basal section of M_3 would produce a venation very like *Dolichopeza*.

Tipula kiushiuensis sp. n.

General coloration gray, the praescutum with four narrow dark brown stripes; wings grayish, with a marmorate subhyaline pattern; vein R_3 strongly arcuated toward R_{4+5}; ninth tergite of male hypopygium with a V-shaped notch, the arms of the notch projecting as short, divergent spines.

Male. Length, 13 mm.; wing, 15 mm.

Female. Length, 16 mm.; wing, 18 mm.

Frontal prolongation of head dark gray, the nasus narrowly tipped with reddish; palpi brownish black. Antennæ with the scapal segments yellow, the flagellum black; antennæ of moderate length, in the male, if bent backward, extending nearly to the base of the halteres. In the female the antennæ are short and only the second scapal segment is yellow. Head yellowish gray, the vertex somewhat darker.

Pronotum high, grayish yellow. Mesonotal praescutum light yellowish gray with four narrow dark brown stripes, the anterior ends of the intermediate stripes obliterated; pseudosutural foveæ reduced to a circular black spot; scutum gray, each lobe with two conspicuous brown spots; scutellum and postnotum brownish gray. Pleura yellowish gray, the sternopleura darker. Halteres yellow, the knobs dark brown with the tips indistinctly paler. Legs with the coxæ yellowish gray; trochanters reddish yellow; femora obscure brownish yellow, the tips rather broadly blackened; tibiæ brown, the tips narrowly darker; tarsi dark brown. Wings grayish, with a marmorate subhyaline pattern much as in the *marmorata* group; cell *Sc* entirely dark brown; stigma oval, dark brown; a small seam at origin of *Rs;* anterior cord and outer deflection of Cu_1 indistinctly seamed with brown; a brown seam behind vein *Cu* and its branches, widest marginally at the tip of Cu_2; the subhyaline areas lie before and beyond the stigma, before and beyond midlength of cells *R* and *M*, near midlength of cell *1st A*, and marginal areas in the ends of both anal cells; veins dark brown, costa more yellowish. Venation: *Rs* a little longer than R_{2+3}; vein R_3 bent strongly toward R_{4+5}, which is bent slightly cephalad, cell R_3 being narrowed at this point as in *Ctenacroscelis;* cell *1st* M_2 large, the cephalic margin arcuated; petiole of cell M_1 about equal to *m; m-cu* preserved.

Abdomen yellow, the lateral margins of the tergites vaguely darker; a subterminal dark brown ring, including segments six to eight, tergite nine and the basal half of sternite nine. Male hypopygium large, the caudal third of the ninth tergite deflected, the margin with a conspicuous V-shaped notch, the lateral angles running out into short black divergent spines. Eighth sternite unarmed, projecting slightly caudad. Ovipositor with long, slender, smooth valves.

Habitat: Japan (Kiushiu). Holotype, ♂, Mt. Kirishima, on boundary between Osumi and Hiuga, altitude 3,250 feet, October 30, 1923, (T. Esaki). Allotopotype, ♀.

Tipula nigrocostata sp. n.

General coloration light gray with darker gray stripes; antennæ elongate, feebly bicolorous; halteres elongate; wings subhyaline, cells *C* and *Sc* brownish black; wings sparsely variegated with darker; male hypopygium with the tergite having a blackened disk, the margin trifid, the median lobe rectangular, the lateral lobes acute.

Male. Length, 13–14 mm.; wing, 15–17 mm.

Frontal prolongation of head grayish, the nasus long and slender, black; palpi brownish black. Antennæ elongate, being approximately one-half the length of the body; basal segment brownish black; second segment brown; first segment of flagellum brown with an obscure yellow ring near midlength; remaining segments with the basal enlargement black, the remainder varying from brownish yellow to dark brown to produce a more or less distinct bicolorous effect. Head yellowish gray, the vertex with an ill-defined brown median line.

Pronotum brownish gray. Mesonotal praescutum light gray with three dark gray to blackish gray stripes, the median stripe cuneiform with the anterior part more suffused with light gray and further divided by a capillary dark brown vitta; scutum gray, each lobe with two blackish gray areas, the posterior mesal one larger; scutellum and postnotum more brownish gray, with a continuous capillary dark brown median vitta. Pleura pale whitish gray, the ventral two-thirds of the anepisternum and the ventral half of the sternopleurite darker gray to produce an indistinct longitudinally striped appearance; dorso-pleural membrane pale. Halteres elongate, dark brown, the extreme base of the stem yellow. Legs with the coxæ pale gray pruinose, especially basally; trochanters yellow, the apex on the mesal face with a conspicuous brown spot; femora brown, the bases paler; remainder of legs black; tarsi long and slender. Wings subhyaline, cells *C* and *Sc* brownish black; prearcular region pale; stigma elongate-oval, dark brown, completely filling cells Sc_1 and *2nd* R_1; anterior cord seamed with brown; cell *M* with a dusky area beyond midlength and another at the outer end, with an irregular area of the ground-color between; anterior cord and adjacent part of *Rs* seamed with brown; wing-apex in the radial cells extensively infuscated; veins dark brown, pale in the subhyaline areas. Venation: *Rs* elongate; terminal section of R_2 preserved, but without macrotrichiæ; petiole of cell M_1 a little longer than *m*; *m-cu* punctiform.

Abdomen with the basal tergites yellowish, passing through yellowish brown to brown on the outer segments, with a median dark brown stripe that is narrowly interrupted at the caudal margins of the segments; sternites obscure brownish yellow, the terminal segments darkened. Male hypopygium small, the tergite of very remarkable form, the disk and apex heavily blackened and chitinized, the margin jutting caudad into a conspicuous rectangular median lobe, the lateral angles of this

chitinized disk acute; the anterior or cephalic margin of the disk with an acute suberect spine on either side of the median line. Basistyles complete, triangularly produced caudad into conspicuous lobes.

Habitat: Japan (Kiushiu). Holotype, ♂, Mt. Kirishima, on boundary between Osumi and Hiuga, altitude 3,250 feet, October 30, 1923, (T. Esaki). Paratopotypes, 3 ♂ ♂. Paratype, ♂, Aburayama, Chikuzen, November 17, 1923, (H. Hori).

Nephrotoma Meigen.

Nephrotoma hokkaidensis sp. n.

Size large, (wing, 15 mm. or more); general coloration yellow; head, scutellum, postnotum and pleura largely gray; wings subhyaline; stigma dark brown; a narrow brown seam along the cord; wing-apex infuscated.

Male. Length, 13 mm.; wing, 15–16 mm.

Female. Length, 20–22 mm.; wing, 15.5–17.5 mm.

Frontal prolongation of the head brownish black; in the male the sides, at apex, yellow; palpi dark brown. Antennæ of moderate length, shorter in female, dark brown, the second segment and apex of the first beneath obscure yellow; flagellar segments moderately incised beneath. Head gray, the anterior part of vertex and the front clear yellow to orange-yellow, the front silvery white laterally; a dark spot on either side at the narrowest point of the vertex, adjoining the eye; genæ, adjoining the eyes, restrictedly pale.

Pronotum whitish, darker laterally. Mesonotal praescutum shiny yellow with three conspicuous shiny black stripes that are distinctly separated; lateral stripes straight; scutum yellow, each lobe with a conspicuous black mark; scutellum dark gray, yellowish laterally; postnotum with the mediotergite broadly gray medially, the lateral margins dull yellow; pleurotergite with a very conspicuous white or yellowish white elongate mark between the bases of the wing and the halteres. Pleura gray, the dorso-pleural region broadly sulphur-yellow; pleurites more or less variegated with pale, including a more or less distinct longitudinal stripe across the mesepisternum. Halteres pale brownish yellow, the knobs clearer yellow. Legs with the coxæ gray, sometimes pale apically; trochanters yellow; femora and tibiæ light brown, passing into darker brown apically; tarsi black. Wings subhyaline; cells *C* and *Sc* more yellowish; stigma dark brown, sending a brown seam along the cord to the posterior margin; wing-apex in cells R_3, R_5 and M_1 narrowly but conspicuously darkened; veins dark brown. Venation: *Rs* longer than R_{2+3}, arcuated; cell M_1 sessile; *m-cu* near the fork of *M*.

Abdomen reddish yellow; first tergite gray; tergites two to six each with a glabrous basal band; the median area of the tergites with the exception of the basal band, dark brown, this area variable in extent; surface of tergites with small yellow setæ; sternites yellow; terminal segments and hypopygium black; outer dististyle pale. Male hypopygium

with the eighth sternite unarmed. In the female, the brown median stripe of the abdomen is more or less continuous and there is, in addition, a very narrow lateral tergal stripe.

Habitat: Japan (Hokkaido). Holotype, ♂, Yoichi, Shiribeshi-no-kuni, June 26, 1921, (S. Kuwayama). Allotopotype, ♀. Paratopotypes, 2 ♂ ♀. Paratypes, ♂ ♀, in copula, Sapporo, Ishikari-no-kuni, June 15, 1921 (M. Hori); 2 ♀ ♀, Sapporo, end of July, 1921, (S. Kuwayama); ♂ ♀, Mt. Moiwa, Ishikari-no-kuni, June 15, 1923, (S. Kuwayama).

Some of the paratypes are in the collection of the Hokkaido Agricultural Experiment Station.

Nephrotoma saghaliensis sp. n.

General coloration yellow, the thoracic markings black; wings faintly yellow, the base and costal region brighter; stigma dark brown; conspicuous macrotrichiæ in the apical cells; abdomen yellow, the terminal segments black; tergites narrowly trilineate with brownish black; a conspicuous capitate appendage jutting from beneath the eighth sternite of the male hypopygium.

Male. Length, 10 mm.; wing, 11.8 mm.

Frontal prolongation of head yellow, the dorsum, including the nasus, dark brown. Antennæ relatively short; scape obscure yellow; basal flagellar segment light brown; remaining flagellar segments brownish black, the incisures of the basal segments a little paler. Head orange-yellow; occipital brand conspicuous.

Pronotum light yellow, dark brown laterally. Mesonotal praescutum shiny yellow, with three conspicuous black stripes; laterad of the cephalic end of the lateral stripe a paler brown spot that gives to the stripe the appearance of being outcurved; scutum yellow, each lobe very extensively marked with black; remainder of mesonotum yellow, the postnotum darker posteriorly. Pleura light brown, variegated with yellow; a conspicuous china-white area on the lateral sclerites of the postnotum between the bases of the wings and halteres. Halteres pale brown, the base of the stem and the knobs yellow. Legs with the coxæ obscure yellow, their bases weakly infuscated; trochanters obscure yellow; femora brown, the tips conspicuously brownish black, very extensive on the fore legs, where about the outer two-fifths is included; tibiæ light brown, the tips rather narrowly but conspicuously blackened; tarsi black. Wings with a faint yellowish tinge, the base and costal region brighter yellow; anal cells grayish yellow; stigma oval, dark brown; obliterative areas before and beyond the stigma and at the fork of *M;* a brown seam on the deflection of R_{1+5} and *r-m*. Conspicuous macrotrichiæ in the distal ends of cells R_3 to *2nd* M_2. Venation: Cell M_1 barely sessile.

Abdomen yellow, the tergites narrowly trilineate with brownish black, the median stripe narrowly interrupted at the posterior margin of

each segment, the lateral stripes more continuous; segments six and seven black, yellowish sublaterally; segments eight and nine black, including the hypopygium. Male hypopygium with a conspicuous slender rod emerging from beneath sternite eight, as in the *cornicina* group, this rod black, the apex capitate, reddish, covered with an appressed pubescence.

Habitat: Japan (Saghalien, Honshiu). Holotype, ♂, Toyohara, Saghalien, August 29, 1921, (S. Kuwayama). Paratype, ♂, Yumoto, Shimotsuke-no-kuni, Honshiu, altitude 4,830 feet, July 23, 1923, (T. Esaki).

Nephrotoma saghaliensis is related to *N. cornicina* (Linnaeus) and *N. aculeata* (Loew) in the conspicuous appendage of the eighth sternite of the male hypopygium. The macrotrichiæ in the distal cells of the wing in the present species are lacking in *cornicina* and *aculeata*.

NEW PHYLLOPHAGA FROM MISSISSIPPI. (COLEOPTERA, SCARABAEIDÆ).

By J. M. Langston,
A. & M. College, Mississippi.

While engaged in the study of the specimens of *Phyllophaga* in the collection at the Mississippi Agricultural and Mechanical College and the specimens collected during the last few years, the writer discovered two forms that seem to be undescribed. Descriptions of these are given below.

Phyllophaga taxodii n. sp.

This species belongs to group VI (dispar* group) according to Horn's synopsis and is very closely related to the species called *dispar* Burm. by Horn (*debilis*, LeC.), but the genitalia are distinct from that species and the specimens slightly larger.

Body elongate, color pale yellowish brown, head darker, thorax very slightly darker than elytra, surface moderately shining, female slightly darker than male. Clypeus concave, margin rather widely reflexed, not emarginate, but there is a small sinuation of the reflexed part of the anterior margin, punctures moderately closely placed toward the margin, less so at the middle posteriorly, punctures closer on female, color slightly lighter than other parts of the head. Front slightly more closely punctured than clypeus, color darker and slightly rufous. Thorax narrowed in front, widest at middle, sides arcuate, (almost angulate in the male) margins indistinctly crenate, punctures moderately close on female, less so on male. Elytral punctures not so well defined as those on thorax, apparently deeper and more closely placed, sutural costæ distinct, discal and submarginal ones indistinct. Pygidium moderately shining, that of male sparsely and indistinctly punctured, punctures of female more closely placed. Metasternum moderately punctured and very slightly hairy. Abdomen finely and sparsely punctured, almost smooth at middle, last ventral segment more deeply and closely punctured at sides than others. Tarsal claws curved, tooth nearer the base than tip, very small in male, larger in female. Last joint of maxillary palpi fusiform and slightly impressed, more slender in female. Length, 12–14 mm., width one-half the length.

Male. Antennæ 9-segmented, club as long as stem. Abdomen very slightly flattened at middle of ventrum, with a slightly raised and roughened triangular area extending from near the middle to the

* According to Glasgow (Bull. Ill. Lab. N. H., Vol. XI, page 372) the name *dispar*, Burmeister, supplants *boops*, Horn. This latter species belongs to group XV, hence the name *dispar* should not be used for group VI.

posterior margin of the penultimate segment. Last ventral segment with a slight depression at middle. This depression bears a variable number of irregular elevations, especially near the anterior margin, which project at right angles to the surface from which they arise. Inner, or fixed, spur of hind tibiæ two-thirds the length of the outer. The genitalia are symmetrical and the claspers do not unite in front. (See species 1, Plate XLIV).

Female. Antennæ 9-segmented, club shorter than stem. Hind tarsi and the spurs of the hind tibiæ approximately the same length as those of male. The pubic process is much like that of *P. debilis*, Lec., but is broader and not so deeply notched at the tip.

Type series consists of holotype, allotype, and ten male and ten female paratypes. Several taken en coitu.

Habitat: Taken near Perkinston, Mississippi, beside a stream known as "Red Creek," by Mr. F. H. Benjamin and the writer in 1921 and Mr. O. M. Chance and the writer in 1922. The collection dates are June 20–25. The only known food plant is cypress (*Taxodium* sp.) from which the species is named. Perkinston is located in the longleaf pine region of South Mississippi.

Phyllophaga micans Knoch, **cupuliformis,** n. var.

This variety is almost identical with typical *micans* in general appearance and has been determined as that species by more than one specialist. The secondary sexual characters, however, as well as the genitalia are distinct from typical *micans*.

Body oblong-oval, widest behind, width slightly more than half the length, slightly depressed, color dark brown to black, pruinose and hence opaque, pruinosity easily rubbed off, especially on the thorax, leaving the surface slightly shining. Clypeus concave, feebly emarginate, border moderately reflexed, moderately punctate. Front less closely punctured than clypeus. Thorax narrowed in front, apparently very slightly wider at base than at middle, sides arcuate, margins indistinctly crenate and slightly ciliate, punctures coarser than those on front and in most specimens slightly more closely placed. Most specimens have a very narrow longitudinal smooth space at middle, sometimes extending the full length of thorax. Basal marginal channel not reaching the disk. Scutellum sparsely punctured, length slightly more than half the width. Punctures of the elytra moderately closely placed and slightly smaller than those of the thorax. Sutural costæ distinct, distal less so, submarginal scarcely evident. Pygidium opaque at sides and base, moderately shining at apex (possibly rubbed at this point), punctures rather coarse and closely placed, those of female slightly more distinct than those of the male. Metasternum closely punctured, hair moderately long and fairly dense. Abdomen opaque, except when rubbed,

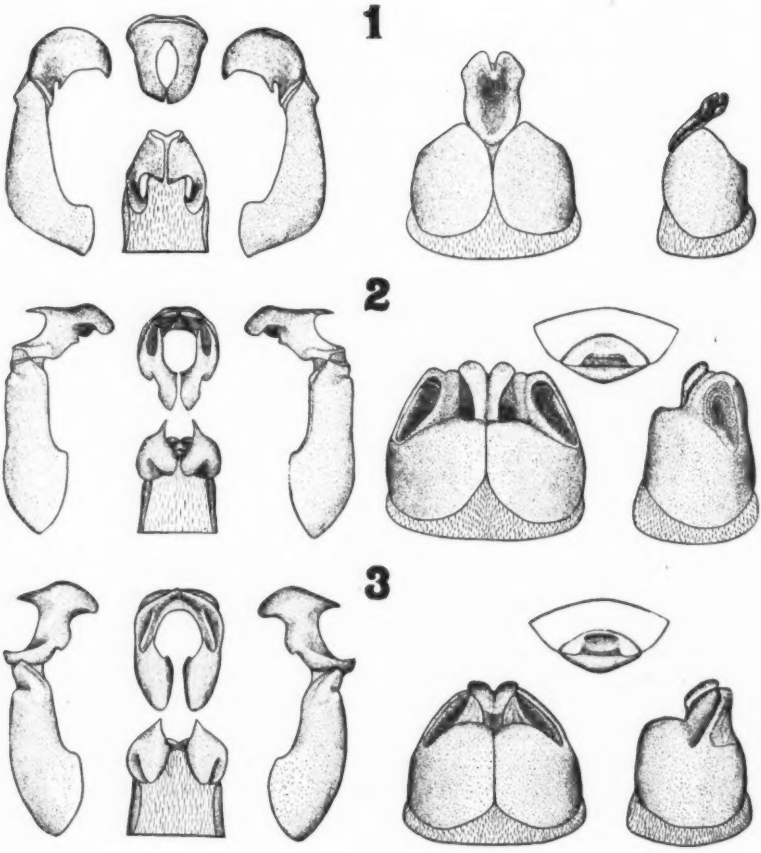
punctures fine and sparsely placed, each bearing a short hair, punctures of female slightly coarser than those of male. Tarsal claws of male curved, teeth of medium size and median, those of female more curved, teeth large and median. Length, 15.5–16.5 mm. Width, 8.5–9.5 mm.

Male. Antennæ 10-segmented, club shorter than stem. Abdomen only slightly flattened at middle of ventrum, a slightly raised curved line at middle of penultimate segment forms the anterior margin of the rather deep cup-shaped depression of the last ventral segment. This depression extends over the posterior half of the penultimate and almost the entire width of the last ventral. Inner spur of the hind tibiæ about half the length of the outer. The genitalia are distinctive, the claspers similar, not uniting in front, somewhat resembling those of *P. crassissima.* (See species 3, Plate XLIV).

Female. Antennæ 10-segmented, club much shorter than the stem, tarsi shorter than those of the male, inner spur of hind tibiæ almost as long as the outer, depression on the last ventral segment always rather deep and broad, anterior margin of the depression steep and rathercl ose to the anterior margin of the segment, depression usually containing a faint longitudinal ridge at the middle.

Type series consists of holotype, allotype, and eight male and eight female paratypes.

Habitat: Specimens have been received from Gulfport, Ocean Springs, and Pass Christian, in the coastal plains section of South Mississippi; and from McHenry, and Saucier, in the longleaf pine area. Taken on live oak, pecan, and at light. April to June. Collected by Messrs. R. P. Barnhart, C. H. Brannon, L. Brown, E. K. Bynum, K. L. Cockerham, K. Harmon, and W. W. Porter, and by Miss Edwina Lindsey. On April 10, 1922, specimens of this variety to the number of 898 were collected, by the use of lanterns placed over tubs containing water and oil, in a pecan grove near Ocean Springs, Mississippi, by Mr. Barnhart and the owner of the grove.



J. M. Langston.

EXPLANATION OF PLATE XLIV.

1. *Phyllophaga taxodii* n. sp. Male and female.
2. *Phyllophaga micans* Knoch. Male, female, and last ventral of female.
3. *Phyllophaga micans* Knoch, *cupuliformis*, n. var. Male, female, and last ventral of female.

All greatly enlarged, the females more highly magnified than the males.

A SECOND NEW MESOVELIA FROM THE DOUGLAS LAKE, MICHIGAN REGION (HEMIPTERA-MESOVELIIDÆ).*

By H. B. HUNGERFORD,
University of Kansas, Lawrence, Kansas.

During the summer season of 1923, while collecting about the region of the Biological Station of the University of Michigan on Douglas Lake, I collected a new species of Mesovelia. This species was taken in Bryant's Bog on the border of Douglas Lake, and was named *Mesovelia douglasensis* Hungerford and described in the Canadian Entomologist for June, 1924. Collections made about the same region during the summer of 1924 have resulted in the capture of many additional specimens of *Mesovelia douglasensis* from Bryant's Bog and the discovery of a new species from another bog. Both species live on the water amongst the densest growths of Chamaedaphne. The most successful way to secure these insects is to walk out upon the densest mats of floating Chamaedaphne, spread the bushes and dip the net into the dark, shady waters. The weight of one's body submerges the bushes somewhat more than usual, and this assists in the use of the net. Without doubt the retiring habits of these small Mesovelia account for the fact that they have remained so long unknown.

The species here described was taken first on June 22, 1924, when four females and five males were collected on my first visit to a pond known as Nichol's Bog. This pond is located in an upland pasture some miles from the Biological Station. It was at one time the site of a saw mill, and large piles of sawdust have been dumped at one end of the pond. Open pasture borders one side, while the other end and side are fringed with growths of Chamaedaphne. It was in the thickest growth of Chamaedaphne, back a short distance from the open water margin that the insects were taken. The diminutive size of these bugs, which resemble *Mesovelia mulsanti* White (= *M. bisignata* Uhl.) somewhat, suggested to me that the species was a new one or a variety of my *Mesovelia douglasensis*.

* Contribution from the Biological Station of the University of Michigan.

A study of these insects under the binocular convinced me that the species was distinct and new, and sent me to the pond again on July 26. A half day's collecting on this date gave me ample material for study. Out of this lot I mounted 24 males and 24 females, and placed the remaining specimens (47 females and 33 males) in alcohol. All specimens are apterous. The description, therefore, is drawn from a study of considerable material. A binocular, equipped with 10x eye pieces and 55 mm. and 32 mm. objectives was used in examining the insects.

Mesovelia cryptophila sp. new.

Size. Female. Length, 2.8 mm.; width across head, 0.52 mm.; width across thorax, 0.65 mm.; width across abdomen, 1 mm. Male—Length, 2.1 mm.; width across head, 0.45 mm.; width across thorax, 0.54 mm.; width across abdomen, .55 mm.

Shape. A slender species, the males cylindrical with thorax about as wide as abdomen. The thorax in both sexes relatively large, both wider and longer relatively than in *Mesovelia mulsanti* White (*M. bisignata* Uhl.). The abdomen of the male thus appears slender and reduced.

Color. Olive green above, the surface more or less frosted with a minute gray bloom, especially on the head and thorax. Dorsal sutural markings of the abdomen dark. General pattern not mottled. Head grayish, marked with the usual three pairs of setiferous black dots and two slender, usually well defined, parallel longitudinal dark stripes on the median line of the head, which at once separates this species from *Mesovelia douglasensis* Hungerford. Prothorax dull brown, except for a lighter ill-defined olive green band along the caudal margin and a median spot which fuses with it. Grayish bloom over all. Mesothorax mostly olive green, the brown confined to two irregular patches. The grayish bloom less dense than elsewhere on thorax, the surface often appearing shiny. Metathorax with the anterior portion dark and posterior part light. Abdomen olive green, usually darker in males than in females. Sides of head and thorax smoky brown, frosted with grayish bloom. Coxal elevations nearly white. Abdomen with strongly impressed, dark reddish brown pleural stripe. Ventral side of head, beak, limbs, and venter pale (almost white, tinged with pale green). The legs, slightly, and antennæ, strongly, infuscated. Entire insect quite pubescent.

Structural Details. Eyes relatively small. Interocular space nearly half the entire width of head, including the eyes. Thorax long, cylindrical. The antennæ slender. The distal end of the first segment surpassing the rear margin of the eye. Second segment shortest. The third segment twice as long as second segment. The fourth segment of same length as third. The formula for the segments of the antenna is as follows: 1st : 2nd : 3d : 4th : : 14 : 11 : 22 : 22. The third and fourth

segments in the male are longer than in the female. The tip of the beak reaches to the distal end of hind coxa. The legs are slender and the front and middle femora do not possess stout spines along the rear margin. Anterior femur and tibia about equal in length; middle femur slightly longer than middle tibia. Hind tibia distinctly longer than hind femur. Tarsi three segmented, the first segment very short. In the front tarsus the third segment is as long as first and second together. In the middle tarsus the second and third segments are about equal in length, while in the hind tarsus the middle segment is plainly longer than the terminal segment. The hind tarsus is less than one-third the length of the tibia. The formulæ for the segments of the legs follow:

	Femur	Tibia	Tarsus
Front leg	20	20	7
Middle leg	26	27	10.5
Hind leg	32	47	13.5

The males lack both the tufts on the first genital segment characteristic of *Mesovelia mulsanti* White and the spines fringing the ventral abdominal segments of *Mesovelia douglasensis* Hungerford. The female lacks the hook-like projections of the penultimate ventral plates.

COMPARATIVE NOTES.

This species is slightly larger and much more slender than *Mesovelia douglasensis* Hungerford. Its grayish, frosty appearance contrasts it with the shiny mottled brown of *M. douglasensis*. There are two slender, parallel, longitudinal lines on head, while in *M. douglasensis* there are two broad brown bands with a slender line between them. The first antennal segment of *M. douglasensis* is stouter, shorter, and more curved, its tip not surpassing caudal margin of eye. The middle segment of the hind tarsus of *M. cryptophila* is both slender and long, conspicuously longer than terminal segment. This new species may be readily distinguished from *M. mulsanti* White (*M. bisignata* Uhler) by its much smaller size, its more prominent thorax, the absence of bristle tufts on the first genital segment of the male, and the absence of hook-like projections on penultimate ventral plates of female. The genital claspers of the males of all three species are distinctive characters.

The three species of Mesovelia now known from America north of Mexico may be separated as follows:

A. Tip of beak reaching only to base of hind coxæ. Row of spines on rear margin of front and middle femora. Males with black tufts of spines on ventral side of first genital segment. . *Mesovelia mulsanti* White (*M. bisignata* Uhler)

AA. Tip of beak reaching nearly to apex of hind coxæ. No row of spines on rear margin of front and middle femora. Males without tufts of spines on ventral side of first genital segment.

B. Two broad longitudinal bands on head with slender line between them. First segment of antenna short, its tip not surpassing hind margin of eye. Middle segment of hind tarsus about as long as terminal segment. *Mesovelia douglasensis* Hungerford.

BB. Without broad bands on head, two slender parallel lines instead. Head and thorax frosted with a gray bloom. First segment of antenna long, its tip surpassing hind margin of eye. Middle segment of hind tarsus slender and plainly longer than terminal segment. . *Mesovelia cryptophila* sp. new.

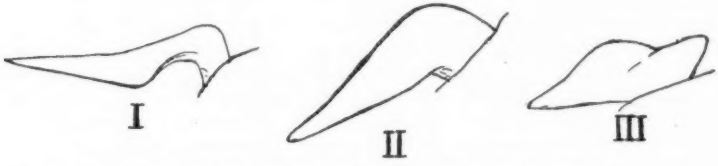


Fig. 1. Freehand sketches of the left genital claspers of male Mesovelias.
I, *M. douglasensis* Hungerford.
II, *M. mulsanti* White (*M. bisignata* Uhler).
III, *M. cryptophila* Hungerford.

The Holotype, allotype, and some paratypes of *M. cryptophila* are in the University of Kansas Entomological Museum. Other paratypes have been sent to the University of Michigan Museum, U. S. N. M., and the private collections of Mr. Torre Bueno, and Doctors Carl Drake, H. M. Parshley, R. F. Hussey, and H. G. Barber.

THE LEAF MINING HABIT IN THE COLEOPTERA.

PART I.

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It is interesting to read the accounts of the Coleopterous leaf-miners in early literature. The accuracy with which their life history notes have been taken and the completeness of the figures, often make it possible to determine the genus of the miner concerned. The first mention of the leaf-mining habit, in this order, appears in Reaumur's memorable work (1737), where he speaks of the "Scarabes." No mention is made of individual species, but he figures a curculionid, with its mine, which he says constructs white silken cocoons, "Coques de soye blanche." He probably referred to the cocoons of *Cionus* or *Orchestes*, although it has recently been discovered that the latter make cocoons of a malpighian secretion. Swammerdam (1758) refers to a species mining in the leaves of alder which, judging from his figures, is that of one of the Hispini. De Geer (1775) likewise mentions the Coleopterous leaf-miners and gives figures of their work on the leaves. One of these is, without doubt, a species of *Orchestes*, mining the leaves of elm. The other is a miner on alder and probably also an *Orchestes*. Kaltenbach (1872), Brischke (1880), Bargagli (1887), and Sorauer (1913) have abundant notes on the habits of the European species. From these a fair idea of the European leaf-mining Coleoptera was gleaned.

During more recent years, several biological studies have been made which have added greatly to our knowledge of the leaf-mining habit in the Coleoptera. Chittenden (1904) contributed a most valuable paper on *Chalepus* and related forms. Tragardh (1910) has given an excellent paper on the metamorphosis and biology of the *Orchestes*. Linnaniemi (1913) speaks generally of the order. Fisher (1922) discusses the leaf and twig-mining Buprestidæ of Mexico and Central

* The present paper deals only with general remarks concerning the mining habit. A second paper is in preparation, a study of the adaptations of the Coleoptera to the leaf mining habit.

America. Chittenden again in 1923, establishes further records of leaf-mining species of *Phyllotreta*. Chapman (1923) gives a life history study of *Taphrocerus gracilis* Say. Hering (1920–1923) has three papers dealing with the leaf-mining Coleoptera as well as leaf-miners of other orders. These papers as well as a few technical papers such as Nicolay and Weiss (1920) and (1923), Blatchley (1910), Blatchley and Leng (1916) and Leng (1919) form a fair basis for study.

The habits of ninety leaf-mining Coleoptera are known from various parts of the world, chiefly North America, Mexico, Central America, Australia, Germany, Italy, Sweden and Denmark. Forty-one of these occur in North America, north of Mexico. There are approximately one hundred and nineteen North American species belonging to the leaf-mining genera. In as much as all the North American genera except *Phyllotreta* are wholly leaf-miners, it is very evident that we are unfamiliar with the habits of many leaf-mining species.

The leaf-mining Coleoptera are particular in the selection of their host-plants. They resemble the Lepidoptera and the Hymenoptera in this respect, but differ from the Diptera which are, as a rule, general feeders. *Brachys* and *Trachys* have been found almost entirely on the woody plants, although there are European records of *Trachys* reared from mines on the leaves of *Malva rotundifolia*. *Taphrocerus* mines *Scirpus*, while *Pachyschelus* is a miner on *Quercus*, *Lespedeza* and *Trifolium*. The Curculionidæ confine themselves to the woody plants. The Chrysomelidæ mine chiefly in the herbaceous plants, although *Zeugophora* and *Chalepus* occur for a large part as miners on the woody plants. *Microrhopala* is found entirely as a miner on asters and goldenrods.

POSITION OF EGGS.

Like the Lepidoptera and the Hymenoptera, the eggs of the leaf-mining Coleoptera are laid either within or upon the surface of the leaves. Probably all the Buprestidæ lay their eggs upon the surface of the leaves. The eggs of *Brachys fulgidus* Fisher, are brown in color, strongly flattened, oval and laid upon the upper surface of the leaf. As far as known, the eggs of all the leaf-mining Curculionidæ are laid singly within the leaves. The leaf-mining Chrysomelidæ, both the Hispini and the

Halticini, lay their eggs upon the surface of the leaves. *Phyllotreta nemorum* Chev., it is said, lays its eggs on the lower side of hairy leaves. In the European genus *Hispa*, certain leaf-mining species often lay their eggs in masses glued to the surface of the leaves.

THE PRESENCE AND ABSENCE OF LEGS.

The mining larvæ are provided with different means of maintaining themselves in position in their mines, while feeding. Some of the larvæ have well developed thoracic legs, while in others they are absent. The larvæ of the Buprestidæ and the Curculionidæ are legless. In the Buprestidæ the larvæ have on the dorsal and ventral surfaces fleshy warts by means of which they move about within their mines. In *Pachyschelus* these warts are highly developed. There is a pair on the prothorax and a pair on the mesothorax, as well as pairs on the second to the eighth abdominal segments. These are well developed on both the dorsal and the ventral aspects of the larva.

In the Chrysomelidæ the thoracic legs may be well developed, as we find in *Chalepus* and in *Phyllotreta* or they may be minute as in *Baliosus*. On the other hand, the larvæ of *Zeugophora* and *Octotoma* are legless. Certain legless species as *Zeugophora abnormis* Lec., have long setæ arising from the thorax and the abdomen. These may aid the larva in its movements within the mine.

It appears that no particular adaptation has occurred in respect to the reduction of the legs for the mining habit. One would think, at first, that the absence of legs would aid the larva in fitting itself to the cramped quarters between the epidermal layers of a leaf, but this has been accomplished, in the leaf-mining species where legs are present, by the greatly depressed body form and in many cases by a blister or tentiform type of mine. The legs, on the other hand, prove as useful to some species within their mines as they do to closely related species that feed openly. They are not as cumbersome or as unnecessary as they are to the boring forms. On the other hand, the miners, which have developed directly through the boring habit as *Trachys*, *Brachys* and *Pachyschleus*, are entirely legless. The larvæ of these three genera are not as highly depressed as the Chrysomelidæ and the absence of legs is

advantageous to the leaf-mining species, as well as the boring forms. Numerous fleshy warts on the dorsal and ventral surfaces of the larvæ serve the function of legs. The presence or absence of thoracic legs, then, has little to do with the mining habit or the adjustment of the larva to this particular manner of feeding. The legs were apparently lost long before the larvæ took on this specialized method of feeding.

TRANSFORMATION.

Transformation may take place within the mine, in silken cocoons or in earthen cells. The Buprestidæ, as far as known, transform within their mines, usually without the construction of a cocoon, although *Pachyschelus* forms a rounded, flattened cell within the leaf. Among the Chrysomelidæ it is possible that all the Halticini make earthen cells in the ground in which they transform, while the Hispini pupate in the leaves. The Curculionidæ; *Orchestes*, *Prionomerus* and *Rhampus* pupate in their mines. *Orchestes* differs in making a spherical cocoon of a leathery malpighian secretion. *Cionus* and *Brachonyx* make open net work cocoons of silk resembling those of *Hypera*, but their texture is much finer.

MINES.

The mines of the Coleoptera are chiefly of the blotch type. Often the mine is blister-like or tentiform, thus making a larger pocket within the leaf. *Dibolia* makes long tortuous mines which seldom become blotched except when many larvæ are mining in the same leaf. *Hippuriphila* and *Phyllotreta* make short linear or serpentine mines, while *Orchestes* starts as a linear mine, but later changes to a blotch-mine.

ORIGIN OF THE LEAF-MINING HABIT.

There are evidences that the leaf-mining habit is ancient in the Coleoptera. The habit appears in three families and in closely related genera within these families. The habit is well established in the order and, where leaf-mining occurs, the genera are, for a large part, entirely of the leaf-mining habit. In North America, *Phyllotreta* is the only leaf-mining genus where the larvæ possess other habits. The majority of the

species of *Phyllotreta* are stem and root-borers or root-feeders, a comparatively few are leaf-miners. None of the leaf-mining species of Coleoptera present a dual habit as we find in the Diptera, an order where the writer considers the leaf-mining habit to be more recent in its development. In *Scaptomyza adusta* Loew (Diptera) the larva voluntarily mines in the leaves of *Brassica* or feeds as a scavanger on decaying vegetable matter. Such a condition indicates that the leaf-mining habit is not completely evolved. Again in *Agromyza laterella* Zett., (Diptera) the larva when feeding on the mature leaves of *Iris*, construct mines, but when feeding in young succulent leaves, form galls. The absence of such instability in the Coleoptera, leads the writer to believe that the leaf-mining Coleoptera have become better adapted to this specialized type of feeding.

It would further look as though the leaf-mining habit had arisen independently in the tree families Buprestidæ, Chrysomelidæ and the Curculionidæ. In the case of the Buprestidæ, there is no doubt that the leaf-mining habit has been developed through the boring habit. The remarkable similarity of the boring and the mining larvæ within this family and the universal boring and mining habits of the species of this family would indicate this.

In the Chrysomelidæ, the mining habit may have developed in two ways. It may have developed through the boring habit in *Phyllotreta*, in a similar way that it has developed in the Buprestidæ. It may also have developed through the scavanger habit. It is easy to imagine that certain external feeders as *Hispa* and *Chaetocnema* first adapted themselves to feed on decaying vegetable matter and later to have gained entrance to the living leaves.

In the Curculionidæ, the mining habit probably developed through the boring forms, although some may have developed through external feeders as in *Cionus*.

A SYNOPSIS OF THE LEAF MINING GENERA OF COLEOPTERA.

Family	Genus	Distribution	No. Desc. Species	‡No. Leaf Mining Species
Buprestidæ	Trachys	S. A., Eur., Asia, Africa	350	6
	Brachys	N. A., Mex., C. A., S. A.	100	4
	Pachyschelus	N. A., C. A., Asia, Africa	164	4
	*Taphrocerus	N. A., C. A., S. A.	43	1
	*Lius	W. I., Mex., C. A., S. A.	75	0
	*Leiopleura	W. I., Mex., C. A., S. A.	85	0
	*Leiopleurella	Panama	1	0
	†Callimicra	Mex., C. A., S. A.	29	0
	†Aphanisticus	Eur., Java	29	1
Chrysomelidæ (Halticini)	Zeugophora	N. A., Eur., Asia, Ceylon	19	5
	†Phyllotreta	N. A., Eur., Siberia, N. Zealand.	46	4
	*Hippuriphila	N. A., Europe	2	1
	†Chaetocnema	N. A., C. A., S. A., Ind., Eur., Sib.	107	1
	Mniophila	Europe, Ceylon	3	1
	Dibolia	N. A., S. A., Cuba, Eur.	36	3
(Hispini)	Microrhopala	N. A., S. A., C. A., Mex.	16	3
	Uroplata	N. A., S. A., C. A., Mex.	55	1
	Octotoma	N. A., S. A., C. A., Cuba	6	2
	Chalepus	N. A., S. A., C. A., Mex.	123	7
	Baliosus	N. A., S. A., C. A., Mex.	24	2
	†Bronthispa	S. A., Australia	6	1
	†Hispa	N. A., Eur., Asia, Africa	75	3
	†Hispella	Europe, Africa, Ceylon	6	1
	†Promecotheca	Asia, Aus.	15	1
	Mantura	Europe	?	1
Curculionidæ	Orchestes	N. A., Eur., Siberia	58	21
	Prionomerus	N. A., S. A., C. A., Mex.	17	1
	Rhampus	Europe	4	4
	†Cionus	Europe	12	1
	†Brachyonx	Europe	2	1
	†Ceutorrhynchus	Europe	?	1

* Probably all the species of these genera are leaf-miners.

† These genera are leaf-miners only in part.

‡ These are the number of leaf-mining species whose habits are well known.

A SYNOPSIS OF THE LEAF MINING COLEOPTERA OF THE WORLD.*

With the Host Plants on Which They Mine.

Buprestidæ.

Trachys fragariæ Bris., on Fragaria collina, Europe (Hyden, 1862). *T. minuta* Linn., on Salix caprea and S. aurita, Europe (Hyden, 1862). *T. nana* Payk., on Convolvulus arvensis, Europe (Hyden, 1862). *T. pumila* Illig. (=minuta Rossi.) on Scabiosa succisa and Stachys recta, Europe (Frauenfeld, 1864). *T. pygamea* Fab., on Malva sylvestria, M. rotundifolia, and Aecaea rosea, Europe (Kaltenbach, 1872). *T. troglodytes* Gyll., (=pumila C. & G.) on Fragaria vesca, Scabiosa succisa and Potentilla recta, Europe (Kaltenbach, 1872).

Brachys aerosa Melsh. (=tessellatus Melsh.), on Ulmus americana and Populus sp., N. Y., (Felt, 1906), on Carya sp., Ind., (Blatchley, 1910), on Tilia sp., Can., and Quercus sp., N. J., (Weiss, 1919), Ind., (Blatchley, 1910). *B. aeruginosus* Gory, on Fagus sp., N. A., (Weiss, 1923). *B. fulgidus* Fisher, on plant similar to Fiscus elastica, Panama (Fisher, 1922). *B. ovatus* (Web.), (=terminans C. & G.) on Quercus sp., Ind., (Blatchley, 1910), N. Y., (Felt, 1906), N. J., (Weiss & Nicolay, 1919), Mo., (Morris, 1916).

Pachyschelus cupricauda Fisher, on a large-leaved forest tree, Panama (Fisher, 1922). *P. laevigatus* (Say) (=ovatus Say.), on Desmodium dillenii, Conn., (Ely, unp.), Md., (Barber & Schwartz, unp.), Mich., (specimens in National Collection), Ind., (Blatchley, 1910). *P. purpureus* (Say), food plant unknown, Ind., (Blatchley, 1910). *P. schwarzi* Kerr., on undet. plant, Fla., (Hubbard & Schwartz, unp.).

Taphrocerus gracilis (Say) on Scirpus fluviatilis, N. A., (Chapman, 1923).

Aphanisticus consanguineas Rits. on Saccharum officinarum, Java (Sorauer, 1913). *A. krugeri* Rits. on Saccharum officinarum, Java, (Sorauer, 1913).

Chrysomelidæ.

(Halticini).

Zeugophora abnormis (Lec.), on Populus sp., Alberta, Sask., (Strickland, 1920), Mont. (Cobb. specimens in U. S. Nat. Mus.). *Z. consanguinea* Crotch, probably a leaf-miner, Ind., (Blatchley, 1910). *Z. flavicollis* Marsh., on Populus sp., Europe, (Kaltenbach, 1872). *Z. subspinosa* Fab., probably a leaf-miner on Populus sp., Europe, (Kaltenbach, 1872). *Z. puberula* Crotch, food plant unknown, Ind. and Ill., (Blatchley, 1910). *Z. scutellaris* Suffr., on Populus sp., Alberta, Sask., (Strickland, 1920), Ind., (Blatchley, 1910), Mont., (Cooley, 1922), N. J. and Wyoming, (larvæ in U. S. Nat. Mus.). *Z. varians* Crotch, Ind., probably a leaf-miner, (Blatchley, 1910), reared as a borer in Populus sp., (Felt, 1906).

Phyllotreta aeneicollis (Crotch), on Lepidium virginica, Col., Tex., La., N. Mex., (Chittenden, 1923). *P. chalybeipennis* (Crotch), on Cakile americana, Mass. and Fla., (Chittenden, 1923). *P. liebecki* Schaeffer, on Lepidium virginica, La., (Chittenden, 1923). *P. nemorum* Linn., on Brassica rapa, Denmark, (Whitehead, 1887). *P. undulata* Kutsch., food plant unknown, Europe, (Omerod, 1890). *P. vittula* Redt. (=vittata Steph.) on Setaria species, Europe, (Sorauer, 1913). *P. zimmermanni* (Crotch) (=sinuata Steph.) on Lepidium virginicum, central and eastern United States, (Beutenmuller, 1890, and Chittenden, 1923).

Hippuriphila modeeri (Linn.) on Rumex crispus and R. obtusifolius N. Y., (writer).

Chaetocnema concinna Marsh, on Rumex species, Siberia, (Sorauer, 1913).

Dibolia borealis Chev. (=aerea Melsh.) on Plantago major, Me., (Patch, 1908), N. Y., (Lintner, 1895), Ind., (Blatchley, 1910). *D. femoralis* Redtb., on Salvia

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* This list contains only the names of the plants on which the Larvæ are known to produce mines. Some of the adults feed on other plants not mentioned in this list.

austriaca, Europe, (Kaltenbach, 1872). *D. rugulosa* Redtb., on Salvia sylvestris, Europe, (Kaltenbach, 1872).

Mniophila muscorum Koch., on Plantago lanceolata, P. media, Teucrium scorodonia and Digitalis purpurea, Europe, (Rye, 1866).

(HISPINI).

Microrhopala floridana Schwartz., on Chrysopsis graminifolia, Wash. D. C., and Fla., (Chittenden, 1904). *M. vittata* (Fab.) on Solidago species, Ind., (Blatchley, 1910), on Solidago laevigata, S. lanceolata, and S. canadensis, Wash. D. C., (Chittenden, 1904). *M. xerene* (Newmn.) on Solidago sp., Ind., (Blatchley, 1910), on Solidago canadensis, S. caecia, S. juncea, Boltonia asteroides, and Sericocarpus asteroides, Wash. D. C., (Chittenden, 1890 and 1904).

Uroplata porcata (Melsh.) on Panicum capillare, Pa., and N. Y., (writer), Ind., (Blatchley, 1910).

Octotoma marginicollis Horn., habits unknown, adults found on Fraxinus sp., Ariz., (Chittenden, 1904). *O. plicatula* (Fab.), on Tecoma radicans, Ind., (Blatchley, 1910), Fla., Tex., Wash., D. C., (Chittenden, 1904), on Lespedeza sp., Ind., (Blatchley, 1910).

Chalepus bicolor (Oliv.) on Panicum macrocarpon, Ind., (Blatchley, 1910), Md., (Chittenden, 1904). *C. dorsalis* Thunb. (=scutellaris Oliv.) on Amorpha fruticosa, Wash., D. C., (Chittenden, 1904), on Betula sp., N. Y., (Felt, 1906), on Crataegus tomentosa, Wash., D. C., (Chittenden, 1904), on Fagus sp., N. Y., (Felt, 1906), on Quercus rubra and Q. alba, N. Y., (Felt, 1906), Wash., D. C., (Chittenden, 1904), Robinia sp. (Lutz, 1918), Robinia pseudo-acacia, Md., (Schwartz, unpublished). *C. horni* (Smith), occurs on Cracca virginiana, N. J., and on Falcata comosa, Ind., (Blatchley, 1910). *C. notatus* (Oliv.), occurs on Tephrosia virginiana, Fla., Va., and Wash., D. C., (Schwarz, unpublished). *C. anoplitis) nervosa* Panz. (=collaris Thunb.), on Aster paniculatus, A. novaeangulæ and A. divaricatus, N. Y., (writer), Aster sp., Wash., D. C., (Chittenden, 1904), Cassia nictitans, Wash., D. C., (Chittenden, 1904), Cornus sp., Ohio, (Houser, 1918), Eupatorium sp., N. Y., (Beutenmuller, 1890), Eupatorium ageratoides, Can., (Chambers, 1872), Pyrus malus, Ohio, (Houser, 1918), Robinia pseudo-acacia, W. Va., (Hopkins, 1890), Ohio, (Houser, 1918), Conn., and Md., (specimens in U. S. Nat. Mus.), Robinia neomexicana, Ariz., (Chittenden, 1904), Solanum dulcamara and Urtica gracilis, N. Y., (writer). *C. scapularis* (Oliv.), on Apios tuberosa, Conn., (Ely, unp.), Kan., (Popence, 1877), Ind., (Blatchley, 1910). *C. omoger* (Chap.), on Robinia species, Va., (St. George, unp.).

Baliosus californicus (Horn), on Ceanothus intergerrimus, Calif., (Chittenden, 1904). *B. ruber* (Weber), on Acer species, Ind., (Blatchley, 1910), Amelanchier canadensis, N. A., (Chittenden, 1904), Betula sp., Ind., (Blatchley, 1910), Carpinus sp., N. A., (Beutenmuller, 1890), Citrus aurantium, Fla., (Chittenden, 1904), Corylus sp., English filbert, (Chittenden, 1904), Pyrus malus, N. Y. and Pa., (writer), Ohio, (Houser, 1918), N. A., (Beutenmuller, 1890), Pyrus arbutifolia, E. U. S., (Beutenmuller, 1890), Prunus sp., Cherry, (Beutenmuller, 1890), Prunus virginiana, E. U. S., (Chittenden, 1904), Robinia pseudo-acacia, C. and E. U. S., (Lutz, 1918), Tilia americana, E. U. S., (Lutz, 1918) and (Chittenden, 1904), Quercus sp., Ind., (Blatchley, 1910).

Bronthispa froggatti Sharp. on Cocos nucifera, Australia, (Froggatt, undated) and (Bignell, unp.), New Guinea, (Sorauer, 1913).

Hispa rosea Weber., on Pyrus malus, N. A., (Beutenmuller, 1890). *H. suturalis* Fab., on Robinia species, N. A., (Beutenmuller, 1890). *H. testacea* L., on Cistus salvifolius, Africa and Europe, (Sorauer, 1913).

Hispella walkeri Zehntn, on Saccharum officinarum, Australia, (Froggatt, undated), Java, (Sorauer, 1913).

Promecotheca antiqua Wse., on Cocos nucifera, Australia. (Froggatt).

Mantura chrysanthemi Koch., on Rumex acetosella, Europe, (Hering, 1921).

CURCULIONIDÆ.

Orchestes alni Linn., (=ulmi De Geer), on Ulmus campestris, Italy, (Bargagli, 1887), on Alnus sp., Europe, (Kaltenbach, 1872) and (Bargagli, 1887). *O. bifascialus* Fab., on Salix russeliana and S. fragilis, Europe, (Kaltenbach, 1872). *O. capreæ* Fab., on Salix russeliana and S. fragilis, Europe, (Kaltenbach, 1872). *O. decoratus* Germ. (=salicis B. & S.), on Salix russeliana, S. triandra, and S. fragilis, Europe, (Kaltenbach), 1872). *O. ferrugineus* Marsh, on Ulmus sp., Italy, (Bargagli, 1887). *O. fagi* Linn., on Populus sp., Sweden (Tragardh, 1910), on Fagus sp., Europe, (Kaltenbach, 1872). *O. iota* Fab., on Myrica gale, Italy, (Bargagli, 1883-87), on Mamestra pisi and Cidaria hastata, Europe, (Kaltenbach, 1872). *O. loniceræ* Herbst, on Lonicera xylosteum, Italy, (Bargagli, 1883-87). *O. loniceræ* Fab., on Lonicera xylosteum, Europe, (Kaltenbach, 1872). *O. pallicornis* Say, on Pyrus malus, Ill., (Forbes, 1911), N. Y., (Leonard, unp.), W. Va., (Frost, 1923), Ohio, (Houser, 1923), Ulmus americana, N. S., (Blatchley & Leng, 1916), Ulmus alata, Tex., (Coad. & Pierce, unp.). *O. populi* Fab., (=fagi Payk.) on Populus niger and P. dialatata, Europe, (Bargagli, 1883-87), Salix alba and S. fragilis (Kaltenbach, 1872), Salix triandra, S. viminalis, and S. laurinea, Europe, (Bargagli, 1883-87). *O. pratensis* Germ. (=waltoni Curt.), on Campanula montana, Centaurea scabiosa, and Centaurea jacea, Europe, (Keltenbach, 1872), Anchusa officinalis, Italy, (Bargagli, 1883-87), Fagus sp., (Curtis, 1827). *O. rufus* Oliv., on Ulmus species, Europe, (Laboulbene, 1880?). *O. rufipes* Lec. (=minutus Horn.), on Salix lucida, Quebec, N. F., Ver., Mass., (Leng, 1916), Conn., (Weiss, 1921), Salix pentandra, Conn., (Weiss, 1921), Populus angustifolia, Utah, (Jones, unp.). *O. rufitarsis* Germ., on Populus sp., (Kaltenbach, 1872). *O. scutellaris* Germ., on Betula sp. and Almus incana, Europe, (Kaltenbach, 1872). *O. signifer* Crtz. (=avellanæ Donov.), on Quercus sp., Europe, (Kaltenbach, 1872). *O. salicis* Linn., on Salix russeliana and S. fragilis, Italy, (Kaltenbach, 1872) and (Bargagli, 1883-87), on Salix viridis, Europe, (Kaltenbach, 1872). *O. sparsus* Falus, on Quercus rubra, Italy, (Bergagli, 1883-87). *O. testaceus* var. scutellaris Zett., on Alnus incana, Italy, (Bargagli, 1883-87). *O. quercus* Linn. (=alni Herbst, rufus Donov.), on Quercus eerris, Q. pedunculata, and Q. rubra, Europe, (Kaltenbach, 1872), Populus sp., Sweden, (Tragardh, 1910).

Prionomerus calceatus (Say.) on Sassafras sp., Conn., (Ely, unp.) Liriodendron tulipiferæ, Fla., and Wash., D. C., (Pierce, unp.).

Rhamphus aeneus Bohm., on Crataegus oxycantha, Italy, (Bargagli, 1883-87). *R. flavicornis* Clairv., on Betula sp. and Crateagus sp., Italy, (Bargagli, 1883-87), Crataegus oxycantha, Europe, (Wellhouse, 1922), Malus species, Germany, Switzerland, and England, (Heyden, 1862), Prunus sp. and Populus sp., Europe, (Wellhouse, 1922), Salix capraea, Italy, (Bargagli, 1883-87). *R. oxycanthae* Marsh., Europe, (Kaltenbach, 1872). *R. subaeneus* Illig., on Crataegus oxycantha, Europe, (Wellhouse, 1922).

Brachonyx pineti Payk., on Pinus sylvestris, Europe, (Bargagli, 1883-87).

Cionus olens (Fab.), on Verbascum pulverulentum, Europe, (Bargagli, 1883-87).

Ceutorhynchus (*Marklissis*) *contractus* Marsh., on Alliaria, Europe, (Hering, 1921).

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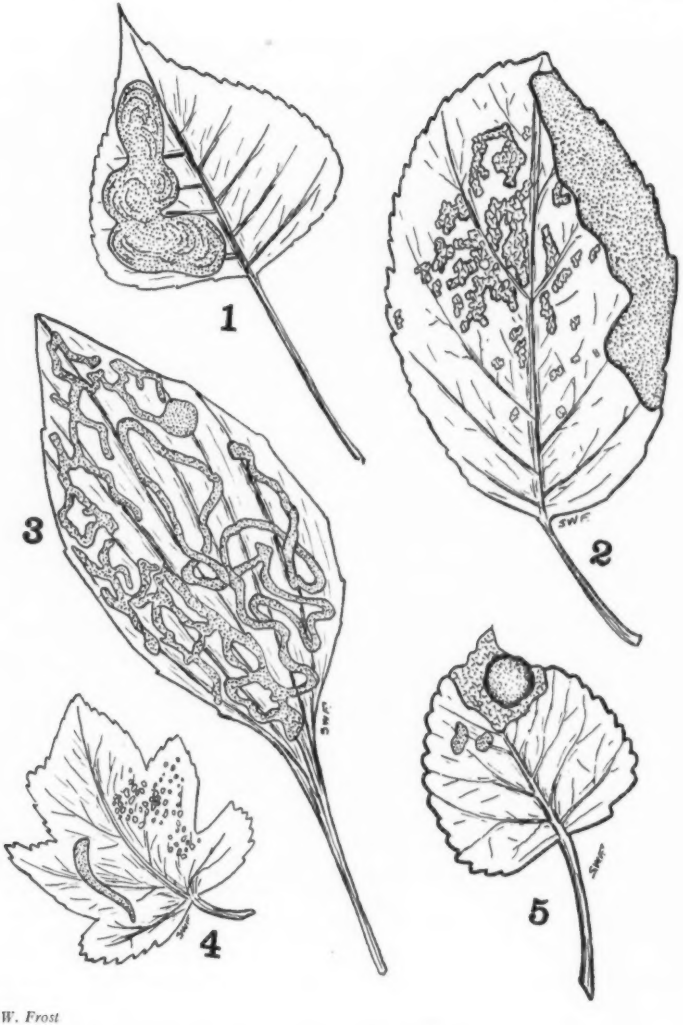

S. W. Frost

Fig. 1. Mine of *Zeugophora abnormis* Lec., on Populus.
Fig. 2. Mine of *Chalepus rubra* Web. on Apple, also showing the feeding scars of the adults.
Fig. 3. Mine of *Dibolia borealis* Chev., on *Plantago major*.
Fig. 4. Mine of *Phyllotreta nemorum* Linn., on seedling leaf Brassica, also showing the feeding scars of the adults. (European).
Fig. 5. Mine of *Orchestes* on apple, showing cocoon within the mine.

THE NEW PINK BORER OF SUGAR CANE AND CORN (LEPIDOPTERA NOCTUIDÆ).

E. K. Bynum, Mississippi Plant Board, and
T. E. Holloway, U. S. Bureau of Entomology.

A large noctuid borer, strikingly pink along the dorsal surface, was found by the writers around Gulfport, Miss., during the last days of May, 1922. They were examining sugar cane for *Diatraea saccharalis*, and not expecting anything new they at first took the new larva to be this species. The junior writer, who has studied *Diatraea* considerably, soon recognized that what they had found was not in this genus, and a careful examination showed the following differences between larvæ of the two species:

Larva of D. saccharalis:	*Larva of new pink borer:*
Maximum size, about an inch in length.	Maximum size, about an inch and a quarter in length.
Head small as compared to body.	Head still smaller as compared to body.
Skin delicate, easily punctured.	Skin very tough.
Proleg hooks or "crochets" in circles on prolegs except those of anal segment.	Proleg hooks or "crochets" only on inner sides of prolegs.
No chitinous plate on anal segment.	Chitinous plate on anal segment.
Body spotted in summer form, spots absent in winter form.	Body strikingly pink along dorsal surface, but this coloration fades out in preserving fluids.

Larvæ of the new species were collected and attempts were made to rear the adult. Methods which are very successful with *Diatraea* were tried, but all these failed. Some larvæ were placed in tin salve boxes, others in holes carefully cut in cane stalks, etc., but all these died. Finally larvæ were put in field cages. One was placed on a leaf of a growing cane plant in such a cage, and it remained for weeks in the same position alive but motionless, exposed to the direct rays of the sun in the day time and to the dews and the comparatively cool breezes of the night. Later the cane from these field cages was cut open and examined. One or two empty tunnels were found, but nothing more. Rearing experiments during 1922 were performed by the senior writer, at Gulfport, Miss., assisted by Mr. L. P. O'Dowd, temporarily employed by the Bureau of Entomology.

In 1923 the senior writer continued field cage experiments, carefully planting growing cane in the cages and later digging away the earth and filling in sand to guard against insects emerging from the soil.

A few larvæ from Gulfport were later kept in very large glass tubes in New Orleans by Mr. W. E. Haley, of the Bureau, and the junior writer. Looking for *Diatraea* in young corn near New Orleans, the junior writer found one of the pink larvæ, and this was transferred to a large tube containing a stalk of cane. All the larvæ in New Orleans gradually died. Repeated search around the city failed to disclose any more of the pink larvæ, either in sugar cane, corn or grass.

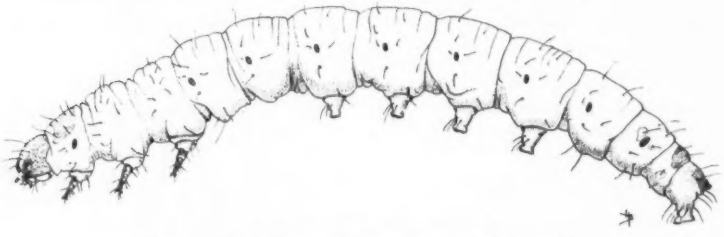

FIG. 1. Pink Borer of Sugar Cane. (Enlarged.)
(Drawing by Harry Bradford, Bur. of Ent.)

During November, 1923, the senior writer began obtaining adult moths from the field cages at Gulfport. Only five moths were obtained altogether, between the 10th and the 28th, though from 30 to 50 borers had been placed in the cages. The moths were brownish, marked with white, with a wing expanse of about an inch. They were submitted to Mr. Foster H. Benjamin, of the Mississippi Plant Board, who was about to describe them under a new genus and a new species when he found that the new form had just been described as *Meropleon cosmion* by Harrison G. Dyar in the current number of *Insecutor Inscitiæ Menstruus* (see Note 1). These specimens were reared from larvæ collected from *Erianthus saccharoides* by C. E. Smith and W. G. Bradley, and submitted to Dr. Dyar by T. H. Jones. They were from Elm Park, West Feliciana Parish, La. A description by Dr. William Barnes and F. H. Benjamin was afterwards published. (See Note 2).

According to the opinions of the writers, based on field examinations covering a period of two years, the pink borer has only one generation during the year. The adults, emerging during the late fall, evidently hibernate. Undoubtedly they come out in the spring, deposit eggs on young sugar cane, corn or heavy grass plants, the eggs soon hatch, and the larvæ reach maximum size in the summer. Pupation doubtless occurs in October. T. H. Jones, quoted by Dyar, writes, "Pupæ were found below the surface of the sand in the breeding jars, and field observations indicate that the larvæ leave the grass stalks in the field and enter the soil to pupate," but the senior writer found pupal skins in the tunnels in sugar cane stalks.

As the larva is so large it makes a tunnel larger than that of *Diatraea*, but as there is only one generation during the year and as the larvæ are apparently inactive much of the time the species is not likely to become an injurious pest. This contrasts with the extreme activity and the many generations of *Diatraea*.

It was thought at first to be an introduced species, possibly coming through the port of Gulfport, Miss., but it now seems likely to be merely a native insect which turns from grass to sugar cane and corn. L. P. O'Dowd found one specimen in grass, and the specimens from Jones were from *Erianthus saccharoides*, "a rank growing grass."

The species has been found on only five properties in Harrison County, Miss., and in two parishes, West Feliciana and Orleans, in Louisiana.

NOTE 1. Description by Harrison G. Dyar, A New Noctuid from Louisiana, Insecutor Inscitiæ Menstruus, XII, pp. 21-22.

Subfamily CUCULLIINÆ.

Meropleon cosmion, new genus and species.

Eyes overhung by long hairs, in a group below and a little in front of the antennæ, not equally distinct in all specimens. Tegulæ not produced behind into a hood; frons smooth; tibiæ and tarsi unarmed; tongue well developed; tegulæ not produced into a dorsal ridge; abdomen with dorsal crests on basal segments; thorax clothed with hair and hair-like scales, a few scales at ends of patagia; palpi with the third joint short; prothorax without crest, metathorax with divided crest; fore wing with the termen shallowly crenulate.

Fore wing dark purplish, shaded with black on the veins centrally, the terminal space light ash-gray; median vein white to its end, the cell filled in with white including or nearly including the oblique elliptical orbicular; reniform diffused, reddish, sometimes with a white inner bar erect from the end of the white median vein, or partly suffused with white; the white in the cell may diffuse to the costa: no distinct lines, the outer line indicated by a double row of dark points on the veins, preceding the terminal ashen area; fringe dark, pinkish. Hind wing pale, pinkish tinged, with a few scattering black scales. Expanse 34–47 mm.

Types, four males and two females, Elm Park, Louisiana, (Smith & Bradley).

NOTE 2. Description by William Barnes and F. H. Benjamin, Contributions to the Natural History of the Lepidoptera of North America, V, 3, pp. 148-149.

Subfamily APATELINÆ.

Meropleon cosmion Dyar.

1924. Dyar, Ins. Insc. Menst., XII, 21, *Meropleon*.

Head and palpi dark rufous-brown; collar similar, but with an additional violaceous-grey tinge; patagia rufous-brown, outlined by black; center of thorax violaceous-grey; metathorax mainly occupied by a large spreading rufous-brown crest edged with darker brown and black; abdomen ochreous-rufous sprinkled with black scales. Primaries: ground color violaceous-grey, suffused with rufous-brown, blackish-brown, and black, and dusted with scattered black scales; costal area as far as the t. p. line violaceous-grey, the same shade occupying the basal area above the median vein, marking the median vein as far as the end of the reniform; the orbicular of the same shade, more or less ovate, oblique, its cephalic mesiad, conjoined to the costal shade, its caudal part distad and conjoined to the shade along the median vein; reniform crescent-shaped, obsolescent, more or less marked by a few black scales, its center rufous, mesially bordered by an excurved violaceous-grey crescent in the cell, connecting the costal and median vein shades; basal line obsolete; t. a. line obsolescent, double, faintly outlined by a few black scales, strongly excurved in submedian space; t. p. line obsolescent, variable in intensity, in some specimens outwardly marked with black, pale, bounded mesially by brownish shades, strongly excurved from costa to about vein 4, running about half way between the discocellulars and the outer margin, incurved below vein 4; a row of dots marking the veins in the s. t. space; true s. t. line obsolescent, pale, waved, its course indistinct; terminal line a brown band mesially and distally marked with a few black scales; a small brown patch between the basal area and the orbicular; a large brown patch filling the cell between the orbicular and the crescent bordering the reniform; a strong, inwardly oblique brown shade from the costa near the apex, fused with a similar shade below the cell which there occupies most of the basal area to the inner margin; s. t. and terminal areas violaceous-grey, dusted with black scales, strongly disconcolorous with the brown areas; fringe with a broad, pale-rufous interline. Secondaries: pale ochreous, dusted with scattered black scales and tinged with pink; fringe pinkish in appearance. Beneath: pale ochreous, dusted with black scales, more or less suffused with pink and violaceous-grey; primaries with terminal line and fringe as on upper side; secondaries with a strong black discal spot, fringe as on upper side.

Expanse: 33–36 mm.

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